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A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Junior shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

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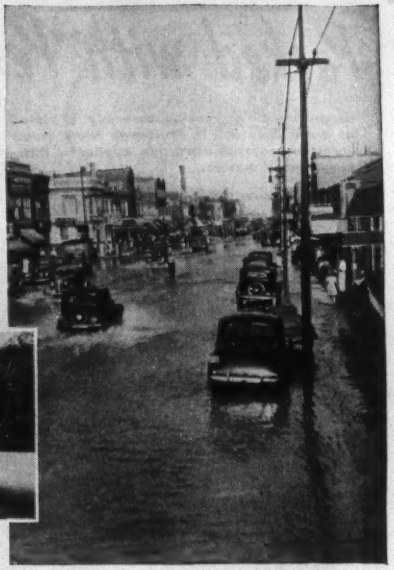

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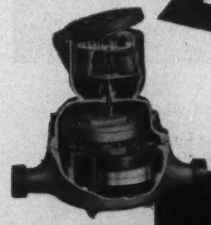

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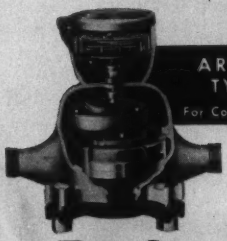

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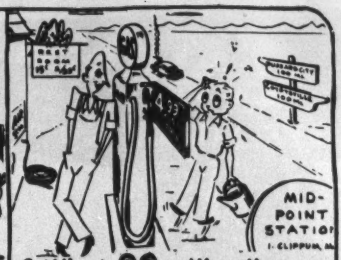

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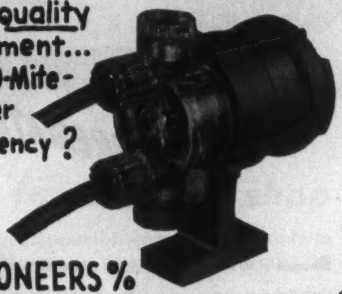

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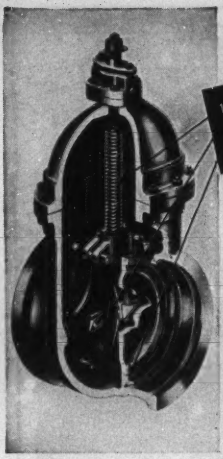

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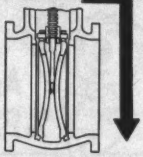
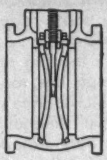


and then OUT



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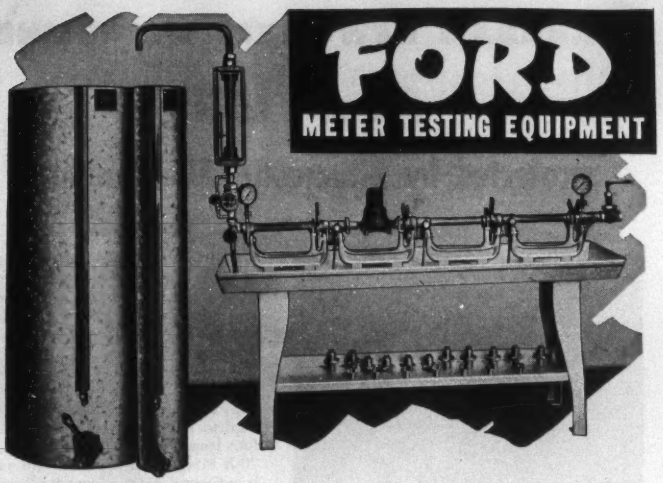

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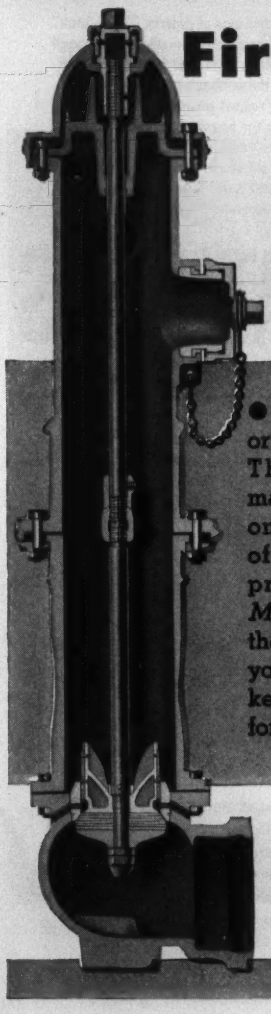

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Table of Contents

PAGE

Water-Distribution Systems Studied by a Complete Electrical Analogy
By Malcolm S. McIlroy 299

The Desalting of Saline Waters: A Review of the Present Status
By Edward W. Moore 319

Memoir of David Edward Moulton 338

Proceedings:

Seventieth Annual Convention 340
Report of the Tellers of Election 343
Award of the Dexter Brackett Memorial Medal 345
Report of the Committee on Reciprocal Relations with the Institution of Water Engineers 348
Commemorative Award 350
Presidential Address by Thomas R. Camp 351
Annual Report of the Secretary 358
Annual Report of the Treasurer 362
Annual Report of the Editor 366
Annual Report of the Finance Committee 369
Annual Report of the Committee on Legislation 372
Report of Technical Program Committee 378
Report of Committee on Membership 380
Report of Committee on Committees 381
Report of Committee on Ground Water Supplies 384
Report of Committee on Rainfall and Yield of Drainage Areas 388
Report of Committee on Specifications for Cast-Iron Pipe and Fittings 389
Report of Committee on Reinforced Concrete Pressure Pipe 390
Progress Report of Committee on Laying Cast-Iron Water Mains 392
Report of Committee on Specifications for Steel Pipe 393
Report of Committee on Standardization of Pipe Flanges and Fittings 394
Report of Hydrant Specification Committee 395
Report of Committee on Gate Valve Specifications 396
Report of Committee on Sluice Gate Specifications 397
Report of Fluid Permeability Committee 398
Report of Committee on Conservation, Development and Utilization of Water Resources 400
Committees of the New England Water Works Association 405

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ORGANIZED 1882

VOL. LXV DECEMBER, 1951 No. 4

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WATER-DISTRIBUTION SYSTEMS STUDIED BY A COMPLETE ELECTRICAL ANALOGY

BY MALCOLM S. McILROY*

[*Presented November 16, 1950.*]

AS PIPELINE networks used in distributing water grow in extent or become more heavily loaded, engineering studies are needed to determine the most economical means of reinforcing them. For example, the proper diameter and routing of new trunk mains, or the elevations and pumping cycles for proposed storage tanks may require consideration. Unfortunately, calculations of flow rates and head losses in complex networks are tedious and must be largely repeated for each proposal for constructing or operating the network. When the procedure described in this paper is followed, these calculations are eliminated and desired values are found directly from the scale readings of instruments, connected to an electric circuit which is a complete analog of the pipeline network.

The use of an electric circuit to represent a pipeline network depends upon the analogies demonstrated in Fig. 1. The upper diagram, Fig. 1A, portrays a simple network of pipelines, which draws water from two sources and discharges it at three points, indicated by D. The lower diagram, Fig. 1B, represents an electric circuit analogous to the pipeline network. When the source rheostats S are properly adjusted, the difference in voltage V′ may be made proportional to the difference in head H′ between the water sources. Likewise, the currents flowing through the load resistors L may be made proportional to desired values of flow rates at the corresponding discharge points. At all times, the current through and the voltage drop across any resistor R are respectively analogous to, but not necessarily proportional to, the flow rate and head loss in the corresponding pipe-

*Professor of Electrical Engineering, Cornell University, Ithaca, N. Y.; Consultant to The Standard Electric Time Co., Springfield, Mass.

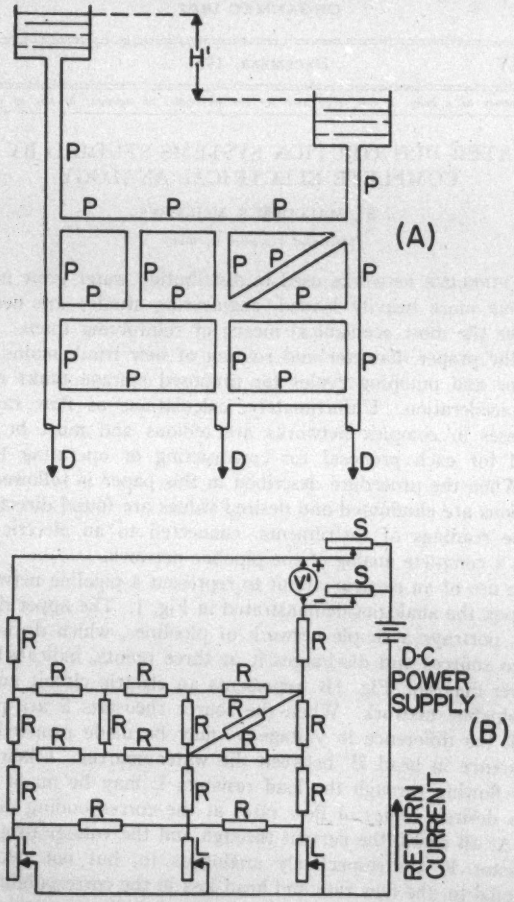

FIG. 1.—PIPELINE NETWORK (A) AND ANALOGOUS ELECTRIC CIRCUIT (B)

line P. Currents in the conductors at circuit terminals and voltages around circuit loops inherently satisfy the requirements that flow rates balance at pipeline junctions and that head losses balance around pipeline loops.

To provide complete proportionality between corresponding quantities in the electric circuit and the pipeline network, the relation between voltage across and current through each resistor must be similar to the relation between head loss along and flow rate through the pipeline it represents. Since this relation is nonlinear, an ordinary linear resistor cannot automatically provide a complete analogy to the performance of a pipeline. When linear resistors represent the pipelines in a network, a successive-approximation procedure must be employed. The resistors are originally set at values assumed to represent the pipelines approximately. The network is energized for a trial run, and values of voltages across and currents through all resistors are recorded. These values do not, in general, conform to the required pipeline performance curves, but the direction and approximate magnitude of appropriate changes in resistor settings are indicated by the results of the trial run. New settings of the resistors are computed and another run similar to the first is made. The process is repeated, if necessary, until all resistors perform properly. References 1 to 4 explain the details of four methods of employing the linear resistors of power-system calculating boards in the analysis of pipeline networks. The time devoted to trial runs and to intermediate computations and adjustments is eliminated when one uses nonlinear resistors specially devised to provide an automatic analogy to the performance of a pipeline.

Complete Representation of Pipelines

The head loss caused by fluid friction in a pipeline varies with the flow rate in a manner which depends upon the nature of the flow. For velocities in the transition range between laminar and fully turbulent flow, the relation may be expressed in the exponential form

$$H = A\, k_p\, Q^a \qquad (1)$$

in which H is the head loss, Q is the flow rate, k_p is the head-loss coëfficient of the pipeline, the value of which depends on the dimen-

sions and condition of the pipe, and A is a constant which depends on the units employed. The exponent x varies as a function of flow rate, ranging from about 1.7 at the lower limit of the transition range up to 2 at the upper limit.

To simplify the solution of hydraulic problems, various authorities have assigned approximate average values to the exponent in equation 1. An approximation which is often satisfactory for use in pipeline-network studies is the Hazen-Williams formula, which may be expressed in the form of equation 1, with x equal to 1.85. This formula gives positive errors in head loss for very low velocities and negative errors for high velocities, which tend to compensate when the formula is applied to all the pipelines of a network. The value of k_p to use with the Hazen-Williams formula is

$$k_p = Ml \tag{2}$$

in which l is the pipeline length in kilofeet and M has the value

$$M = \frac{5{,}830}{d^{4.87}C^{1.85}} \tag{3}$$

In equation 3, d is the pipe diameter in feet, and C is the Hazen-Williams smoothness coëfficient. Values of the constants M and A are listed in Tables 1 and 2, respectively, in the Appendix.

The special nonlinear resistors used for the direct analysis of pipeline networks perform over the significant range of operation according to the relation

$$V = k I^{1.85} \tag{4}$$

in which V is the voltage across the resistor terminals, I is the current through the resistors, and k is called the coëfficient of the resistor. Equation 4 is analogous to the Hazen-Williams formula, with the following quantities respectively proportional:

$$\begin{aligned} V &\sim H \\ I &\sim Q \\ k &\sim A\,k_p \end{aligned} \tag{5}$$

The resistors which have the nonlinear characteristic of equation

4 are comprised of tungsten filaments, supported on heavy nickel leads in evacuated glass bulbs. If a tungsten filament in a vacuum is unaffected by cooling from the leads, the voltage along it varies very nearly as the 1.63 power of current through it. If advantage is taken of this cooling effect by designing the filament and leads with suitable dimensions, the value of the exponent for the whole filament may be raised from 1.63 to the desired value of 1.85. For each standard filament diameter, a certain range of values of k may be realized. The combined range of coëfficient values which results from the use of all commercially-available diameters of tungsten covers a ratio of approximately 20,000 to 1, which is adequate to represent the lengths and diameters of pipelines usually present in an analysis of a water-distribution system. The method of designing the nonlinear resistors is explained in detail elsewhere (5).

Nonlinear Resistors in Operation

In addition to representing the Hazen-Williams formula for a wide range of pipeline dimensions, the special tungsten-filament resistors have other useful properties. All resistors, regardless of the values of their coëfficients, operate normally over the same range of voltage, 0 to 4.6 volts, and at any given voltage within the range of incandescence all their filaments glow at nearly the same color and brightness. Since head loss is proportional to voltage, the brightnesses of the various filaments give a rough indication of the relative head losses in the corresponding pipelines. The most serious head losses are indicated by the brightest filaments. To obtain actual values of the head losses, readings of a voltmeter connected in turn to the various filaments must be recorded.

The resistors are customarily manufactured with about 200 different combinations of filament and lead dimensions, to give values of coëfficients k arranged in a series of numbers, spaced at intervals of approximately 5%. This choice of interval is a satisfactory compromise between accuracy and manufacturing cost. Any pipeline may be represented by a resistor, the coëfficient of which has a value within approximately $\pm$ 2.5% of the desired value. If a resistor having a desired coëfficient is not available, it may be represented by an equivalent series or parallel combination of resistors. The resultant

value of the coëfficient of a series or parallel combination may be found by simple rules.

Representation of Loads

Although discharges from a pipeline network are usually randomly distributed along the pipes, they may be represented, except under special circumstances, by equivalent concentrated loads connected at the pipeline junctions (6). In most problems, required flow rates at loads are given, and it is desired to determine the corresponding flows and head losses in the distribution pipelines. In the electric circuit, this situation is represented by load currents which are independent of the voltages available at the load-circuit terminals. To promote speed in adjusting the loads to desired values in a large network, load-current control devices should be used. Constant-current ballast lamps have been found satisfactory for this purpose. A typical characteristic curve of a ballast lamp is shown in Fig. 2. Current, I_L, through the lamp varies as a peculiar function of voltage, V_L, across the lamp. Over a fairly broad range of voltage, the current is nearly constant. To assure operation within this range of voltage, an adjustable rheostat is placed in series with the lamp. By observing an ammeter connected in the load circuit, the person conducting the analysis can easily adjust the series rheostat so that the lamp operates in its constant-current range. Ballast lamps are available in a range of current ratings which is suitable for pipeline-network analysis. For finer, fully automatic control, electronic circuits may be used. These circuits involve higher cost, more space, and more complicated wiring.

Conversion from Hydraulic to Electric Quantities

Three conversion factors are involved in representing a pipeline network by an analogous electric circuit with nonlinear resistors. The first two factors are

$$B = \frac{V}{H} \quad \text{volts per unit head loss} \tag{6}$$

and

$$G = \frac{I}{Q} \quad \text{amperes per unit flow rate} \tag{7}$$

The third factor, which relates the resistor coëfficients, k, to the pipeline head-loss coëfficients, k_p is

$$\theta = \frac{k}{k_p} = \frac{A\,B}{G^{1.85}} \tag{8}$$

Values of the ratio $\frac{B}{G^{1.85}}$ are listed in Table 3 of the Appendix for preferred values of B and G. As in equation 1, the constant A may be evaluated from Table 2.

Steps in Conducting an Analysis

The procedure of analyzing a pipeline network is illustrated by the following sample instructions:

1. Draw a map of the pipeline network to be analyzed.

2. Compute the values of the coëfficients k_p in equation 2 for all pipelines and insert them on the pipeline map. For example, in Fig. 3, the trunk main between source S-1 and the network is a 20-inch pipe, 3400 ft long, with a smoothness coëfficient of 120. The value of M from Table 1 is 0.0696 and the value of k_p is, from equation 2,

$$k_p = Ml = 0.0696 \times 3.4 = 0.237 \tag{9}$$

3. Select values of the conversion factors. The head-loss conversion factor, B, is chosen so that the average voltage per nonlinear resistor is roughly 2.5. Along the upper and right sides of Fig. 3, seven pipelines are in series between source S-1 and the lower right-hand corner. The total head loss between these two points is estimated to be roughly 40 ft. If the average voltage per pipeline is 2.5, the value of B would be approximately $2.5 \times \frac{7}{40}$, or 0.44 volt per foot head loss. From the preferred values listed in Table 3, the value of B is chosen as 0.5 volt per foot head loss.

The flow-rate conversion factor, G, is selected next. The range of discharge flow rates specified in Fig. 3 is from 0.27 to 2.11 mgd, and the normal range of available ballast-lamp ratings is from 0.1 to 2 amperes. A value of G equal to 0.5 ampere per mgd gives load cur-

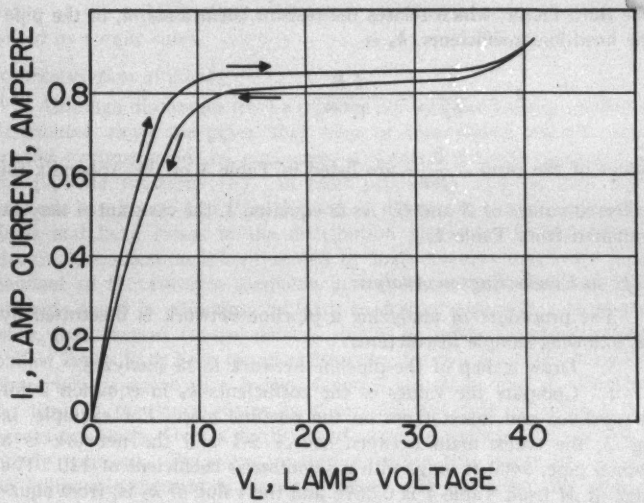

FIG. 2.—TYPICAL CURRENT-VOLTAGE CHARACTERISTIC OF BALLAST LAMP

rents from 0.135 to 1.055 amperes, which are satisfactory; hence this value of G is selected.

Since flow rates are expressed in mgd and heads in feet of water in this problem, the value of the constant A is 1.807, from Table 2. The value of $\frac{B}{G^{1.85}}$ is 1.81, from Table 3. Hence the conversion factor θ has the value

$$\theta = 1.807 \times 1.81 = 3.26 \qquad (10)$$

4. Prepare a circuit diagram, Fig. 4, arranged exactly like the pipeline network map. Show on this diagram the difference of voltage to be maintained between any pair of sources. Since $B = 0.5$, the voltage between S-1 and S-2 is $10 \times 0.5 = 5$ volts. Also show the required load currents, each of which is equal to G times the discharge rate in mgd. The value of each resistor coëfficient, k, corresponding to

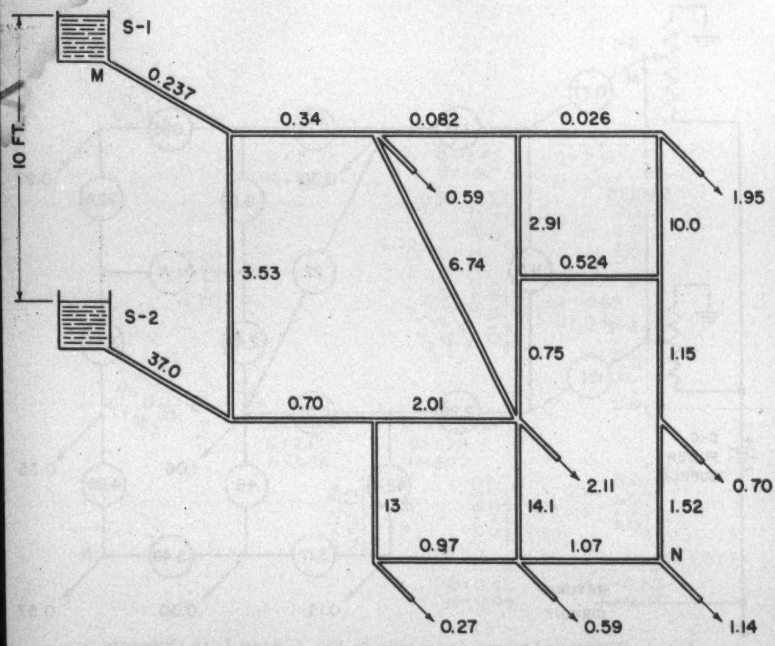

FIG. 3.—PIPELINE NETWORK WITH VALUES OF DISCHARGE RATES IN M G D

each pipeline element, is shown in a circle. For example, the trunk main from source S-1 is represented by a resistor, the coëfficient of which has the value

$$k = \theta\, k_p = 3.26 \times 0.237 = 0.77 \qquad (11)$$

5. Connect the electric circuit according to Fig. 4 and energize it by gradually raising the power-supply voltage. Adjust all load currents and the voltage difference between sources to the proper values. During this process, watch the filaments of the nonlinear re-

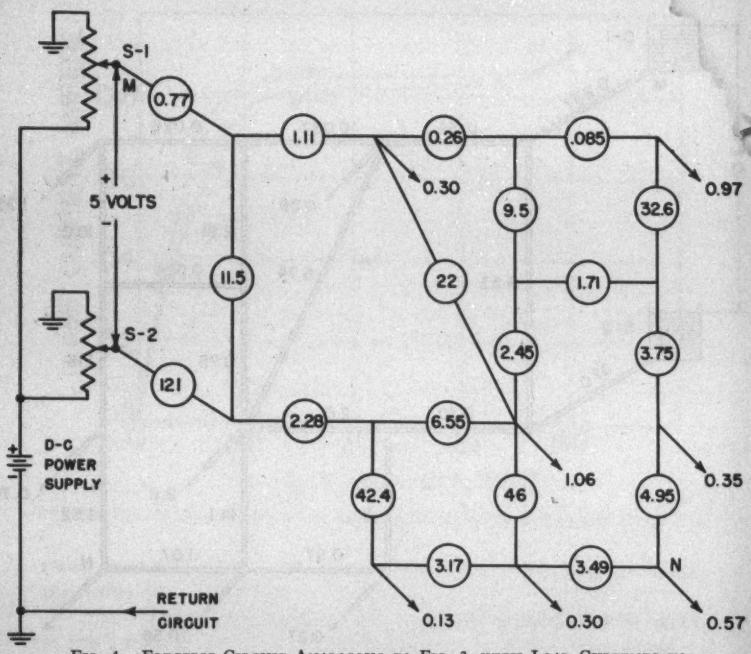

FIG. 4.—ELECTRIC CIRCUIT ANALOGOUS TO FIG. 3, WITH LOAD CURRENTS IN AMPERES

sistors and replace those that tend to glow too brightly with equivalent series combinations.

6. When all specified conditions are reached, read from master instruments the desired values of head losses and flow rates. Since the instruments may be provided with specially calibrated demountable scales, they give indications directly in hydraulic terms.

7. Record results of the analysis on a map, such as Fig. 5. The results shown here are arbitrarily adjusted very slightly to give perfect balances. Values as read from the instruments may have insignificant balance errors.

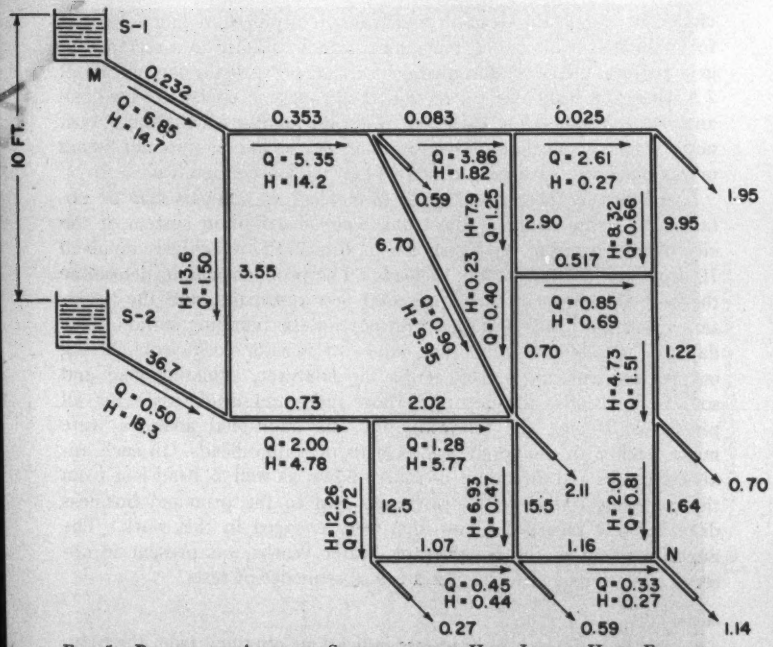

FIG. 5.—RESULTS OF ANALYZER SOLUTION, WITH HEAD LOSSES, H, IN FEET AND FLOW RATES, Q, IN M G D

Pipeline-Network Analyzer

To perform the analysis in an efficient manner, apparatus constructed for the purpose is needed. This equipment, called a pipeline-network analyzer, provides a permanently-connected basic grid system, having sockets in which the nonlinear resistors may be inserted, together with the necessary controls for source voltages, spaces for load devices, and instruments and plugging jacks for measurement of head losses and flow rates. The original model, which is located at Cornell University, is illustrated in Fig. 6. Arrangements are in-

cluded for connecting sources and loads to any desired junctions, and for making special connections which do not conform to a rectangular grid pattern. Because the average voltage per resistor is only about 2.5 when the head-loss conversion factor B is properly selected, an analyzer may be safely operated to permit analyses including almost any number of pipelines. Over 50 analyses, including some for steam or gas pipelines, have been conducted on the Cornell analyzer.

An idea of the time required to conduct an analysis may be obtained from the study of the trunk water-distribution system of the city of Binghamton, N. Y., shown in Fig. 7. This analysis involved 70 pipelines, 5 sources and 15 loads. The problem was to determine the best elevations of three proposed new reservoirs, and the necessary discharge heads and pump ratings for the pumping station. One day was devoted to computing values of resistor coëfficients, laying out the electric circuit, connecting the analyzer, adjusting load and source conditions, and recording flow rates and head losses for all pipelines. During the following day, six additional analyses were made, each with a different set of loads or source heads. In each analysis, values and directions of source flows, as well as head loss from the pumping station to all reservoirs and to the principal business district, were recorded. Two men were engaged in this work. The Superintendent of the Binghamton Water Works was present to observe operations and to suggest a useful sequence of tests.

Accuracy

The overall error in head-loss indications obtained from the pipeline-network analyzer has always been conservative and has been less than three per cent. Methods of evaluating accuracy are presented elsewhere (7). To obtain maximum accuracy, the procedure described here may be modified to correspond to rational laws, such as the Colebrook-White adaptation of the basic relation

$$H = \frac{flv^2}{d2g} \tag{12}$$

This modified procedure is described in reference 7. Head losses obtained from an analysis employing the relation of equation 12 usually differ insignificantly from an analysis based entirely on the Hazen-Williams formula.

FIG. 6.—PIPELINE-NETWORK ANALYZER

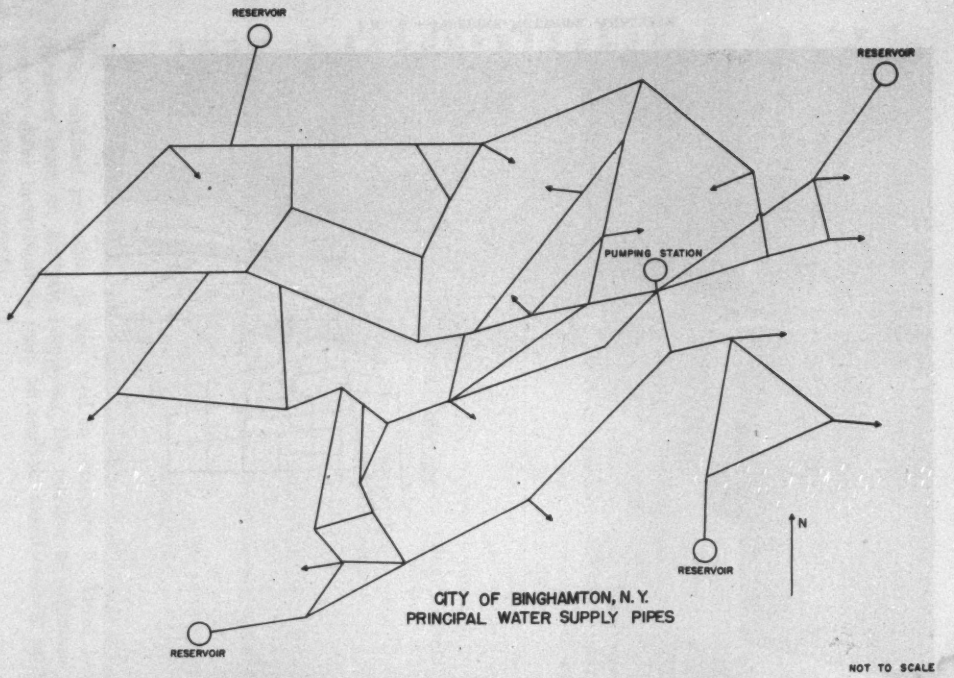

FIG. 7.—SKELETONIZED DISTRIBUTION NETWORK, CITY OF BINGHAMTON, N. Y.

Conclusions

An electric circuit which is the complete analog of a pipeline network may be realized when special nonlinear resistors are used to represent the pipelines. When these resistors are employed, solutions of network problems are direct, requiring no successive approximations. The attention of the analyzer operator is drawn to the seriously loaded portions of the network by the relative brightnesses of the resistor filaments. Only those quantities which are interesting or important need be measured. Results of an analysis are given directly in hydraulic units and automatically balance within satisfactory engineering accuracy. The complete electrical-analogy process is particularly advantageous when comparisons are required among various proposals for network construction or operation. Once the analyzer has been connected to represent a general pipeline network, the effects of changes in details may be evaluated rapidly. The analyzer is, in effect, an automatic model of a pipeline network.

Acknowledgment

The writer is indebted to several members of the New England Water Works Association for assistance rendered during his basic work leading to the development of the pipeline-network analyzer. This work was the subject of a doctorate thesis, completed at Massachusetts Institute of Technology (8) under the supervision of Dr. Harold L. Hazen, Head of the Department of Electrical Engineering. The original idea for devising an electric pipeline-network analyzer was conceived by Thomas R. Camp, who has addressed the Association previously on this subject (1, 9). Both Camp and Prof. Allan T. Gifford of M.I.T. gave the strongest possible encouragement and technical aid during the basic research.

The following members of the N.E.W.W.A. gave valuable help by supplying maps of water-distribution systems and comments about their engineering or operating experiences: S. C. Beane of Weymouth, R. W. Esty of Danvers, C. B. Hardy of Worcester, T. E. Kennedy of Fitchburg, A. C. King of Taunton, R. G. Oakman of Needham, and C. M. Saville of Hartford. Mr. R. H. Ellis, of Associated Factory Mutual Fire Insurance Companies of Boston, formulated a study of

the Cornell campus water-distribution system and assisted in the conduct of the ensuing analysis as an early test of the analyzer. Two New England manufacturers, Sylvania Electric Products, Inc., of Salem, and The Standard Electric Time Co., of Springfield, made significant contribtuions to the development.

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TABLE 1.—VALUES OF M, EQUATIONS 2 AND 3, PER 1000 FEET OF PIPE

	Inside diameter of pipe in inches													
C	4	6	8	10	12	14	16	18	20	24	30	36	40	C
140	130.	18.4	4.50	1.53	0.625	0.295	0.154	0.0869	0.0516	0.0215	0.00718	0.00298	0.00178	140
135	139.	19.7	4.81	1.63	0.669	0.315	0.165	0.0928	0.0551	0.0229	0.00768	0.00318	0.00190	135
130	149.	21.1	5.17	1.75	0.717	0.338	0.177	0.0995	0.0592	0.0247	0.00825	0.00342	0.00204	130
125	160.	22.7	5.55	1.88	0.770	0.363	0.190	0.107	0.0636	0.0265	0.00885	0.00367	0.00219	125
120	173.	24.5	5.99	2.02	0.830	0.392	0.205	0.115	0.0696	0.0286	0.00955	0.00396	0.00226	120
115	187.	26.5	6.48	2.19	0.900	0.425	0.222	0.125	0.0743	0.0309	0.0103	0.00429	0.00257	115
110	203.	28.7	7.03	2.38	0.975	0.460	0.241	0.135	0.0806	0.0335	0.0112	0.00465	0.00279	110
105	222.	30.8	7.53	2.60	1.06	0.501	0.263	0.148	0.088	0.0366	0.0122	0.00508	0.00303	105
100	242.	34.2	8.38	2.84	1.16	0.549	0.287	0.161	0.096	0.0400	0.0133	0.00555	0.00331	100
95	263.	37.8	9.25	3.13	1.28	0.605	0.317	0.178	0.106	0.0441	0.0147	0.00612	0.00366	95
90	295.	41.6	10.20	3.45	1.41	0.668	0.349	0.196	0.117	0.0486	0.0163	0.00675	0.00403	90
85	328.	46.2	11.30	3.84	1.57	0.741	0.388	0.218	0.130	0.0540	0.0181	0.00755	0.00448	85
80	366.	51.9	12.70	4.30	1.76	0.830	0.435	0.244	0.145	0.0605	0.0202	0.00839	0.00500	80
75	412.	58.3	14.30	4.83	1.98	0.935	0.489	0.275	0.164	0.0681	0.0227	0.00945	0.00565	75

TABLE 1.—VALUES OF M, EQUATIONS 2 AND 3, PER 1000 FEET OF PIPE (*Continued*)

C	Inside diameter of pipe in inches						C
	42	48	54	60	66	72	
140	0.00139	7.35×10^{-4}	4.16×10^{-4}	2.45×10^{-4}	1.53×10^{-4}	1.01×10^{-4}	140
135	0.00148	7.86	4.45	2.62	1.63	1.10	135
130	0.00159	8.44	4.78	2.81	1.75	1.17	130
125	0.00171	9.07	5.13	3.02	1.88	1.26	125
120	0.00184	9.78	5.54	3.26	2.02	1.36	120
115	0.00200	1.06×10^{-3}	6.0	3.52	2.19	1.47	115
110	0.00217	1.15	6.5	3.82	2.38	1.60	110
105	0.00236	1.25	7.09	4.17	2.59	1.74	105
100	0.00258	1.37	7.75	4.56	2.84	1.90	100
95	0.00285	1.51	8.55	5.03	3.13	2.10	95
90	0.00314	1.67	9.43	5.54	3.45	2.32	90
85	0.00349	1.85	1.05×10^{-3}	6.16	3.83	2.57	95
80	0.00390	2.07	1.17	6.90	4.3	2.88	80
75	0.00440	2.33	1.32	7.77	4.83	3.24	75

TABLE 2.—VALUES OF THE CONSTANT A FOR FRESH WATER, EQUATIONS 1 AND 8

Units used for flow, Q	Units used for head loss, H	
	Feet of water	Pounds per sq in
US gpm	10^{-5}	4.34×10^{-6}
Hundreds of US gpm	0.0501	0.0217
US mgd	1.807	0.783
Imperial gpm	1.401×10^{-5}	6.07×10^{-6}
Hundreds of Imperial gpm	0.0702	0.0304
Imperial mgd	2.53	1.098
Cfs	0.807	0.350
Thousands of cu ft per hr	0.0754	0.0327

TABLE 3.—VALUES OF THE RATIO $\frac{B}{G^{1.85}}$

Values of G	Values of B								
	0.025	0.05	0.1	0.25	0.5	1	2.5	5	10
0.0025	1,628.	3,255.	6,510.	16,280.	32,550.	65,100.	162,800.	325,500.	651,000.
0.005	452.5	905.	1,810.	4,525.	9,050.	18,100.	45,250.	90,500.	181,000.
0.010	125.0	250.	500.	1,250.	2,500.	5,000.	12,500.	25,000.	50,000.
0.025	23.0	45.9	91.8	230.	459.	918.	2,300.	4,590.	9,180.
0.05	6.37	12.75	25.5	63.7	127.5	255.	637.	1,275.	2,550.
0.10	1.77	3.54	7.09	17.7	35.4	70.9	177.	354.	709.
0.25	0.325	0.65	1.30	3.25	6.5	13.0	32.5	65.	130.
0.50	0.0905	0.181	0.362	0.905	1.81	3.62	9.05	18.1	36.2
1.0	0.0250	0.050	0.100	0.250	0.50	1.00	2.50	5.0	10.0
2.5	0.0046	0.0092	0.0184	0.046	0.092	0.184	0.46	0.92	1.84
5.0	0.00127	0.00255	0.0051	0.0127	0.0255	0.051	0.127	0.255	0.51
10.	0.000353	0.000705	0.00141	0.00353	0.00705	0.0141	0.0353	0.0705	0.141

THE DESALTING OF SALINE WATERS: A REVIEW OF THE PRESENT STATUS*

BY EDWARD W. MOORE**

[*Read December 21, 1950.*]

BY FAR the largest portion of the waters of the globe is unfit for potable, agricultural, or process use by reason of excessive content of dissolved salts. These waters are termed saline or brackish waters; they can be divided into two principal groups: sea water and brackish waters produced by admixture of fresh waters with sea water, and saline surface and ground waters deriving their salinity directly from geological formations. The distinction is somewhat arbitrary, since the salinity of the sea originated from, and is being constantly augmented by, the leaching of soil and rocks, while numerous saline surface and ground waters take their salts from ancient ocean deposits.

However, the difference is readily recognized in practice. Sea water is practically constant in composition at about 3.5% to 3.6% total dissolved solids throughout the world, and brackish waters derived from sea water retain this constancy of composition in large degree, with dilution modifying only the total soluble content. T. Sollman (1) gives the following composition for sea water: NaCl, 2.7%; KCl, 0.075%; $MgCl_2$, 0.37%; $MgBr_2$, 0.0027%; $MgSO_4$, 0.23%; $CaSO_4$, 0.14%; $CaCO_3$, 0.003%. Saline surface and ground waters, on the other hand, exhibit the widest possible variation in total solubles and in the kinds of salt present. The lower limit is determined only by the level at which one wishes to apply the term "saline" in contradistinction to "fresh," and the upper only by the saturation values of the various salts.

In many regions, some of which are of potential value, the supply of fresh water—i.e., water that can be adapted to water-supply requirements at relatively little cost—is limited or non-existent, but

*From a report by the author to the Subcommittee on Water Supply of the Committee on Sanitary Engineering & Environment, Division of Medical Sciences, National Research Council.

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suitable quantities of saline waters are available. If such regions are to be used without the excessive burden of transporting adequate supplies of water means must be found to reduce the salt content of the saline waters to acceptable levels at the lowest possible cost.

Objections to Saline Waters

The objections to high salt content in potable water supplies are based on two factors: taste and physiological effects. Sodium chloride, for example, is recognized in water by most people at concentrations of 300 to 900 ppm; it becomes objectionable enough to curtail consumption of the water at about 1,000 to 1,500 ppm. Richter and MacLean (2), in a study of 53 adults, found that the average level of recognition for sodium chloride was 870 ppm and the median level 650 ppm. G. C. Whipple, in "The Value of Pure Water" (Wiley, 1907), has cited the results of tests on the ability of a limited number of observers (10 to 20) to detect various mineral substances in water. These results are given below:

Substance	Range of concentrations detected (ppm)	Substance	Range of concentrations detected (ppm)
NaCl	200-450	$CaCl_2$	150-350
KCl	350-600	$CaSO_4$	250-900
$NaNO_3$	450-800	$CaCO_3$	50-200
Na_2SO_4	250-500	$MgCl_2$	200-750
NaOH, KOH	1- 50	$Mg(NO_3)_2$	500-800
Na_2CO_3	15- 75	$MgSO_4$	400-600

From Whipple's results it is apparent that most of the neutral salts are detectable in concentrations of the same order of magnitude as sodium chloride. The objectionable levels for these salts would probably also be about the same as those for sodium chloride. Alkalies, such as sodium and potassium hydroxides, sodium carbonate, and calcium carbonate, can be detected at lower levels and would become objectionable at much lower concentrations. Dole has expressed the opinion that waters exceeding 300 ppm of carbonate, 1,500 ppm of chloride, or 2,000 ppm of sulfate are apparently intolerable to most people. The U. S. Public Health Service drinking-water standards are also pertinent: the permissible pH value is limited to 10.6 and the

normal carbonate alkalinity to 120 ppm; magnesium should not exceed 125 ppm, and both chloride and sulfate are limited to 250 ppm. These restrictions are not absolute, however, and waters containing higher concentrations than those specified may be used if better sources of water are not available.

The non-toxic neutral salts produce major physiological effects only when ingested at concentrations materially above isotonic levels. At these concentrations they produce dehydration of internal tissues, resulting in nausea and, if ingestion is continued, in the death of the organism. For sodium chloride the isotonic level is 7,500 ppm; a concentration of 10,000 ppm induces vomiting. Other neutral salts have similar effects at concentrations of the same order of magnitude. Water containing such large amounts of salts would rarely be used, even in emergency.

Minor physiological effects are produced by some of these salts at lower levels of concentration. These effects manifest themselves in gastric disturbances and catharsis; they are particularly noticeable in persons using a water of high solids content after being accustomed to water containing only small quantities of dissolved solids. They are believed not to produce any permanent damage, and it is well known that one can acquire tolerance for waters of comparatively high salt content. Magnesium, sulfate, and phosphate ions, when ingested in quantities of 1 to 2 grams, produce active catharsis. This would limit the tolerable concentrations of these ions to about 1,000 to 2,000 ppm. According to Sollman (1), concentrations of NaCl below 7,500 ppm and of magnesium or sulfate below 1,000 ppm are harmless.

A collection of material loaned to the author by Dr. Lawrence T. Fairhall of the U. S. Public Health Service has been the source of considerable information on the use of waters of high salt concentrations. For example, Pub. No. 99 of the Carnegie Institute, entitled "Botanical Features of North American Deserts," by D. T. MacDougal, makes the following statement:

> "Experience of the field expeditions . . . demonstrates that saline or alkaline water containing as much as 2500 parts per million of salts may be used for many days without serious discomfort . . . if increased to 3300 parts per million, only hardened travellers may use it. . . . 5000 parts per

million is inimical to health and comfort, though it might suffice for a few hours, or save the life of a person who had been wholly without water."

Water Supply Paper No. 333, page 33, of the U. S. Geological Survey has statements to the effect that waters containing 1,060 to 1,300 ppm of chloride are used without ill effect and considered to be of good quality. The same is true of water containing 1,550 ppm of sulfate. A water containing 2,100 ppm of sodium carbonate is used by many persons with no bad effect. Water Supply Paper No. 343, pages 134-136, states that waters containing up to 2,500 ppm of total solids are considered satisfactory where calcium is high and chloride low; waters of 2,500 to 4,000 ppm are considered potable, though inferior, and are avoided if the chloride content is high. A few waters of 4,000 to 5,000 ppm are used; one contains 4,800 ppm of total solids and 188 ppm of chloride. A ranch water containing 3,044 ppm of total solids, of which 139 are chloride and 2,009 sulfate, is considered satisfactory.

It is evident from the foregoing that waters containing comparatively high concentrations of dissolved salts—at least 2,500 to 3,500 ppm—can be used without adverse effects by those accustomed to them and that tolerance of such waters can be acquired by most people. However, it must be borne in mind that many saline waters may contain definitely toxic components, such as barium, selenium, boron, and arsenic. These are harmful at quite low concentrations and must be given special consideration in any effort to reduce or eliminate salts from water.

High salt concentrations are also undesirable for agricultural purposes. The salts in irrigation water tend to become concentrated in the soil by evaporation and eventually restrict or prevent the growth of vegetation. According to L. V. Wilcox (3), the factors which influence the salinity of the soil, and hence the limiting salinities of waters used in irrigation, are the permeability of the soil [greater permeabilities allow use of more saline waters], the quantity of water used, the rainfall, the climate, the method of irrigation used, and the crop species. Among the species of ions that may be present in the water, sodium is most objectionable; it tends to reduce the soil permeability and to create an alkaline condition. Hence it is

necessary, in examining waters for agricultural use, to consider not only the total salt concentration, but also the proportion of sodium present; this is expressed usually as an equivalent percent of the total cations. Potassium has an effect similar to that of sodium, but it is usually present in smaller amounts than sodium, is less injurious per unit of concentration, and is also an essential nutrient, so that it rarely is a significant factor. Calcium and magnesium tend to be beneficial by keeping the soil permeable.

Certain toxic elements, notably boron, are highly injurious to plants; the allowable boron content of water for agricultural use is sharply limited. Selenium is less toxic to plants, but tends to be absorbed into them and produce toxic effects in animals consuming the plants.

Carl S. Schofield (4), as quoted by Wilcox, has classified waters with respect to their suitability for irrigation as shown in Table 1.

The quality requirements for industrial process waters are highly variable from one industry to another and no general statement can be made. Many industries have to impose limitations on the concentrations of dissolved salts that are even more stringent than those for potable waters. These limitations are more often concerned with particular ions than they are with the total concentration of dissolved salts.

In summary, it may be said that there is a real need for an economical process that will reduce the salt content of saline waters, preferably to less than 500, but in any case to less than 1,000 ppm, and at the same time eliminate any toxic ions that may be present.

Available Methods of Desalting

At present there are but two methods of desalting saline waters that approach economic feasibility: evaporation and ion-exchange demineralization. Recent developments have lowered costs for both methods and research is being actively prosecuted on each of them. It is not impossible that radically different methods may be developed, but none have been extensively reported to date, although electro-osmosis and freezing have been given some consideration. Both evaporation and ion-exchange are theoretically capable of producing

TABLE 1.—CLASSIFICATION OF IRRIGATION WATERS

Class of water	Conductance, $K \times 10^6$ at 25°C.	Total dissolved solids (ppm)	Na equivalent, % of total cations	Boron (ppm) for crops, rated as Sensitive	Semi-tolerant	Tolerant
Excellent	0- 25	0- 175	0-20	0.00-0.33	0.00-0.67	0.0-1.0
Good	25- 75	175- 525	20-40	0.33-0.67	0.67-1.33	1.0-2.0
Permissible	75-200	525-1,400	40-60	0.67-1.00	1.33-2.00	2.0-3.0
Doubtful	200-300	1,400-2,100	60-80	1.00-1.25	2.00-2.50	3.0-3.75
Unsuitable	over 300	over 2,100	over 80	over 1.25	over 2.50	over 3.75

water satisfactory for all purposes from almost any saline water, and the choice between them would be determined largely on the basis of cost, mobility, and other engineering factors.

Thermal evaporation, in which solid, liquid or gaseous fuel is burned to provide heat and the steam thus produced from the saline water is re-condensed to yield distilled water, is at present the most widely used method of evaporation. The equipment may be single-effect—i.e., one evaporator and one condenser—or multiple-effect, in which the latent heat of the steam from the first evaporator shell is used to boil additional saline water in a second shell at lower pressure, and so on. Double- and triple-effect evaporators are common, and quadruple and quintuple effects are in use in many large stationary installations. They achieve impressive fuel economies over single effects, but at greater capital cost and the sacrifice of compactness and mobility. The single-effect evaporator is simple and compact, but produces the lowest yield of water per pound of fuel consumed of all evaporation methods. Saline water is used as condenser cooling water in evaporator installations and part of this cooling water feeds the evaporator. Additional heat recovery is obtained by heat exchange between evaporator feed and evaporator blow-down.

The vapor-compression evaporator, a comparatively recent development, operates on the principle of the heat pump. Vapor produced at atmospheric pressure from the saline water is withdrawn from an evaporator shell, compressed, and returned to a condensing chamber in the evaporator shell, where its latent heat is given up to evaporate more saline water. A three-way heat exchanger transfers additional heat from the distilled water produced and from the evaporator blow-down to the incoming saline feed. A heating element to raise the water in the evaporator to starting temperature completes the system. The fuel or energy economy of this system is materially greater than that of the multiple-effect evaporators, while in compactness and cost it compares favorably with the single-effect. The vapor-compression evaporator is a notable advance in distillation technique. At present it is available only in units with a capacity of a few hundred gallons per hour, but development of larger units is in progress.

Solar evaporation is attractive in principle, since many regions

deficient in fresh water have high solar irradiation levels. However, successful solar stills are as yet limited to units of small capacity. In one instance, numerous small units have been combined to produce a capacity of 1,000 gal per day (5). During the war a solar still for lifeboats was developed, having a capacity of about one quart per day; in package form it occupied about the same space as one quart of water. In the course of this development it was shown that about 55% of the solar heat received by the collector could be transformed to latent heat of evaporation in a system collecting the vapor by means of recycled air. Solar evaporation has possibilities for remote areas where a very modest supply of water would be required and complete freedom from the necessity of shipping fuel or chemicals would be an important consideration.

Complete removal of dissolved salts by ion exchange became possible as a result of two discoveries in the late 1930's: one, the discovery that acidic groups, particularly sulfonic acid groups, attached to solid organic media, would reversibly remove cations from water passed through these media and substitute hydrogen ions therefor; the second, the development of synthetic resinous materials, containing basic groups that would absorb these hydrogen ions, together with the anions present in the water. In general terms, the two reactions involved are as follows:

Cation exchange

Removal and regeneration

$$\left.\begin{matrix}2M^{+}\\M^{++}\end{matrix}\right\} + H_2Z \rightleftharpoons \left\{\begin{matrix}M_2Z + 2H^{+}\\MZ\end{matrix}\right.$$

Anion exchange

Removal

$$R_3N + H^{+} + \left\{\begin{matrix}X^{-} \longrightarrow R_3N \cdot HX\\ \tfrac{1}{2}X= \qquad\quad \cdot H(X)_{\frac{1}{2}}\end{matrix}\right.$$

Regeneration

$$2R_3N \cdot HX + Na_2CO_3 \longrightarrow 2R_3N + 2Na^{+} + 2X^{-} + H_2O + CO_2$$

The essential equipment consists of a filter shell, containing the cation exchanger, followed by one containing the anion exchanger. A degasifier may be necessary as a third item in the sequence, if large amounts of carbonates or bicarbonates are present. A recent development is the mixed-bed exchanger, which contains the cation and

anion exchangers in a single filter shell. The result is a considerable saving in weight and bulk, at the expense of complicating the regeneration procedure. Other operating advantages are secured and the process is more efficient than the two-bed system. The single-bed system may, in the future, extend the range of applicability of ion exchange in the desalting of water.

The processes are rapid, so that the filters need not be large to secure high capacities. Cation exchangers will handle 2 to 2.5 gpm per cubic foot of bed, and anion exchangers up to 1.7 gpm per cu ft.

The chemicals required for the process are commercial sulfuric acid, used at a strength of 2% to regenerate the cation exchanger, and sodium carbonate, used at a concentration of 2% to 5% for regeneration of the anion exchanger. Sodium or ammonium hydroxide may also be used for regeneration of the anion exchanger and hydrochloric acid for the cation exchanger. A significant portion of the treated water must be used to rinse and backwash both cation and anion beds after regeneration. Economies can be effected by various systems of partial re-use of regenerant solutions and rinse waters.

The kinds of salts present in the water exert a great deal of influence on the ion-exchange process, whereas this is comparatively unimportant in evaporation. Cation exchangers remove divalent cations such as Ca^{++} and Mg^{++} somewhat more readily than they remove Na^{+} and K^{+} or, expressed in another way, a cation exchanger will begin to "leak" Na^{+} or K^{+} before the multivalent ions begin to appear in the effluent. The anions present also influence the efficiency of the cation exchanger; for example, Na^{+} is most readily removed when associated with HCO_3^{-}, less readily when associated $SO_4^{=}$, and least readily when associated with Cl^{-}. In other words, anions that form weak acids with the hydrogen ion given off by the cation exchanger facilitate its operation. Anion exchangers are also affected by the kind of ion present; for example, $SO_4^{=}$ is much more readily removed than Cl^{-}. It is generally conceded that a saline water containing a high proportion of sodium chloride compared with other salts is one of the most difficult waters to treat by exchange methods.

Not all anions are removed by the ordinary anion exchangers;

those that are the anions of very weak acids come through the anion bed as the undissociated acids. Examples are H_2CO_3, H_2SiO_3 and H_2F_2; some of the toxic ions are also in this category, e.g. H_3BO_3. Within the last two years, however, anion exchangers have been synthesized containing highly basic groups that remove these weak-acid anions completely. These materials are used in a second-stage anion exchanger, which removes the last remnants of anions; it must be regenerated with sodium hydroxide.

While the total concentration of salts present in the feed has only a secondary effect on the productivity of an evaporator, the amount of desalted water produced by an ion-exchange system between regenerations is a direct function of the total salt concentration of the water. For the ion-exchange system, then, the cost per gallon of treated water can be expressed almost entirely in terms of the initial salt concentrations of the feed, and for high salt concentrations, such as those prevailing in sea water, requirements for regeneration and rinse will consume practically the whole product of the system. Therefore, in its present state of development ion-exchange is sharply limited in its applicability. It is unsuitable for waters containing more than about 2,500 ppm of dissolved salts, except in special forms, such as the silver zeolite used for emergency demineralization of sea water. However, in view of the rapid development now taking place in ion-exchange, it would be rash to assume that such limitations are permanent.

Costs and Operating Requirements

It is difficult to obtain reliable and unbiased information on the comparative costs and labor requirements for the various methods of desalting. Many general cost figures are quoted, but these are usually given without analysis or with incomplete analysis, so that it is difficult to determine what cost elements are included. Many of the quoted figures are estimates only; this is particularly true of vapor-compression distillation and ion-exchange. With these limitations in mind, certain general statements may be made as to operating costs; in none of the figures quoted are capital costs included.

In thermal evaporation, the principal cost item is fuel; labor and maintenance are secondary. The salt-concentration of the water dis-

tilled influences primarily the latter two items, although the fuel cost is increased to some extent by the increased heat loss resulting from the necessity for increasing the rate of blowdown for the more saline waters. The increased rate of blowdown is necessary to prevent excessive scaling and objectionable carry-over, both of which are dependent on the concentration of the water in the evaporator body. Cost figures on thermal evaporators are usually based on the production of distilled water for process use; no allowance is made for the possibility of blending the product with raw water to produce a supply satisfactory for general use. This fact must be considered in comparing the cost of evaporation with that of ion-exchange demineralization, which is usually calculated on a partial-removal basis. The figures for operating cost per thousand gallons of water produced by double-effect evaporation are usually quoted as $1.00 to $2.00 per thousand gallons, depending mainly on fuel costs. Large multiple-effect installations may cut costs to as low as $0.75 per thousand gallons, and small single-effect evaporators, operating under adverse conditions, may go as high as $4.00 to $6.00 per thousand gallons. Aultman's estimates are the most recent; he states that fuel costs alone would amount to $2.60 per thousand gallons in a single-effect still and $1.07 in a triple-effect system. There is no present reason to expect any large reduction in these costs through new increases in the efficiency of thermal evaporators.

As a result, the vapor-compression still appears to be a formidable competitor of the direct-fired still. Although cost data at present are limited to very small units, these seem able to produce distilled water at about $1.00 to $1.25 per thousand gallons. Direct-fired installations of comparable size cannot compete with these vapor-compression units in economy. Larger vapor-compression units are in process of development and will almost inevitably show reduced operating costs; claims are being made that the larger units will produce water at $0.50 per thousand gallons.

Cost figures on solar distillation are non-existent. Presumably they would consist almost entirely of capital and maintenance costs, and at present these would be greater than those of other methods. Provision of considerable reserve capacity and storage to carry over

extended sunless periods would be a factor. Solar distillation is in a much less advanced state of development than thermal or vapor-compression distillation or ion-exchange; however, it cannot be entirely dismissed.

In demineralization by ion-exchange, the principal factors in operating costs are the cost of chemicals for regeneration, labor charges, and cost of replacement of the resins. Of these, the first item is the largest and the best known; the second and third items exist largely as estimates.

Bachmann (6) has published graphs for computing chemical costs for complete demineralization by ion exchange. For a water containing 1,000 ppm each of cations and anions, his data give a chemical cost of 22.5 cents per thousand gallons, with 66° Bé. H_2SO_4 at $20 per ton and 98% Na_2CO_3 at $25 per ton. The cost is linear between 0 and 1,200 ppm for both cations and anions. It is to be expected that detailed cost analyses would show material differences between waters containing differing proportions of the various anions and cations, because they are not all removed with equal ease. Labor costs have been variously estimated as 15 to 30 cents per thousand gallons. As to resin-replacement costs, Gustafson(7) suggests that they may be as high as 6 to 40 cents per thousand gallons. Excluding capital charges, the total cost for complete demineralization of water containing 1,000 ppm each of anions and cations would range between 43.5 and 92.5 cents per thousand gallons.

The following estimates, given by Dr. Walter P. Juda of Ionics, Inc., and based on experience in operating a pilot plant at Rehovoth, Israel, are presented for comparison:

COST OF DEMINERALIZATION (CENTS PER 1,000 GAL.)

Salts Removed (ppm):	500	1,000	1,500	2,000
Conventional Demineralization	23 - 28	42 - 47	60 - 65	75 - 80
Ionics Partial Demineralization	18 - 23	26 - 31	33 - 38	45 - 50
Ionics Partial Demineralization with Lime Regeneration	8 - 10	12 - 14	17 - 19	22 - 24

The Ionics process involves special patented features, such as counterflow of water and regenerant solutions with partial bed regen-

eration, resulting in high chemical-utilization efficiencies. The demineralization is deliberately kept incomplete in this process. Further economies are obtained by a special process allowing the use of lime as regenerant for the anion exchanger.

From the foregoing it is apparent that waters of relatively low mineral content can be demineralized by ion-exchange at costs somewhat lower than those of the evaporation processes. At about 2,500 ppm of total salts, the costs of the ion-exchange process begin to exceed those of the more efficient representatives of the evaporation processes, and above this level costs of ion-exchange desalting rapidly become prohibitive in its present state of development.

The labor requirements for the operation of these desalting processes are of perhaps more interest than are the over-all cost figures. Published information is negligible; the little information cited here has been secured by conversation and correspondence with individuals.* A battery of twelve 60-gal-per-hour oil-fired stills would require two to three men per shift. Presumably, manpower needs would increase but little as the capacity of the units increased within reasonable limits. In addition to the regular operating requirements, there is the necessity for periodic descaling of each unit; this occurs about every 700 hours of operation when distilling sea water. The descaling would require about 12 hours' time for two men.

According to information received from R. S. Warner, Jr., of the staff of Arthur D. Little, Inc., the operation of vapor-compression stills is simpler than that of oil-fired stills. One man per shift should be able to take care of a battery of as many as 12 stills. Operation is substantially automatic, and the duties of the operator are mainly to keep the fuel supply adequate and the water intake lines clear. Again, periodic descaling at intervals of about 700 hours is necessary, and this requires two men for about 12 hours.

With regard to the labor requirements for ion-exchange, A. H. Vallez of the Dorr Co., in correspondence with the writer, has offered the following information:

"About the only labor required for an ion-exchange installation is for regenerating the cells, and that is a constant, regardless of the size of the cells, and amounts to roughly 2½ hours per cycle. . . . The

installed cost of ion-exchange equipment is relatively high, and, for producing fairly large amounts of deionized water at a uniform flow rate, the most economical arrangement would probably consist of several pairs of cells, so arranged that one pair was always out of service being regenerated while the other pair, or pairs, were in service. An installation of this type could be readily taken care of by one man and a helper per shift. For producing relatively small amounts of treated water the installation usually consists of a single pair of cells, sized to provide fairly long operating cycles, with a treated water storage tank to satisfy the demand during the period when the cells are out of service for regeneration. Labor requirements amount to about three man-hours per cycle, and cycle lengths may range from about six hours to as long as a week or more when treating water of low dissolved solids content."

Bacteriological Quality of Desalted Waters

Both direct-fired evaporators and vapor-compression stills, when properly constructed, installed and operated, will produce water free from bacterial contamination, even though the feed is highly contaminated. The vapor-compression still is reported to produce a water of particularly good quality, sterile and free from pyrogens. There are, however, two ways in which the product of stills can suddenly become contaminated with little or no advance warning. One is by carry-over—that is, the passage of droplets of feed-water and concentrate into the condenser; the other is by leakage of contaminated feed into the product in condensers and heat-exchangers. In the vapor-compression still under normal operating conditions, leakage from the feed-water to the product is unlikely, since the distilled-water side is at a higher pressure than the feed-water side. This is not true of direct-fired stills. Conductivity meters or periodic chemical tests will detect contamination. The ideal equipment is a recording conductivity meter, which actuates an alarm when the conductivity of the distillate begins to increase. Carry-over will not occur in a properly designed still of either type, provided that temperatures, pressures and blow-down rates are maintained within the design limits; but in actual operation it is sometimes difficult to conform to these requirements.

Chlorination of the distillate should therefore be provided for, if it is to be regularly used as drinking water.

Effluents from ion-exchangers will retain much of the original bacterial content of the feed and will require thorough disinfection as a matter of routine. Claims have been made that a mixed-bed ion-exchanger will produce a sterile effluent, but it is difficult to see why this should be so. There is also a tendency for bacteria to multiply in ion-exchange beds and considerable difficulty is encountered in disinfecting these beds. Chlorine or hypochlorites cannot be used to disinfect the organic cation- and anion-exchangers, as the chlorine attacks the exchanger and is itself destroyed. Special agents, such as chlormelamine, must be employed (8).

Physical Quality of Desalted Waters

Undesirable constituents, such as color and turbidity, are completely removed by distillation methods under normal operating conditions; they would appear in the product only when carry-over or leakage was taking place. Ion-exchange beds will not remove color and turbidity to any substantial degree, and these components would have to be removed by pre-treatment of the water, if present in objectionable amounts. This still further restricts the area in which ion-exchange can compete with distillation, by increasing the cost and the amount of equipment required.

Neither process is very effective in removing the more common components producing tastes and odors in water. Most of these components are volatile substances and will come over in a distillate, although perhaps in reduced amounts. The "flat" taste commonly attributed to distilled water is undoubtedly due to volatile taste- and odor-producing components, rather than to absence of dissolved gases. Very few of the taste- and odor-producing substances would be expected to be susceptible to removal by ion exchange. It is very probable that any taste and odor difficulties encountered would have to be met by subsequent treatment of the desalted water, no matter which process was used.

Comparative Water Yields per Unit of Material Consumed

It is of interest to compare the yield of water per unit weight of fuel or chemicals consumed in the various processes. Campobasso (9) states that 1,000 B.T.U. produce 2.32 lb of water in an oil-fired quadruple-effect evaporator and 10.8 lb of water in a Diesel-driven vapor-compression still. If fuel oil is taken as 18,500 B.T.U. per lb, these figures represent yields of 43 and 200 lb of water per lb of oil consumed, respectively. Experimentally, yields of up to 240 lb of water per lb of oil have been obtained from vapor-compression stills. A single-effect evaporator yields about 12 lb of water per lb of oil. From Bachmann's cost figures for de-ionizing a water containing 1,000 ppm each of anions and cations, of which 244 ppm are bicarbonate, a requirement of 6 tons of sulfuric acid and 4 tons of soda ash per mil gal of water de-ionized is indicated. This represents a gross yield of over 400 lb of water per lb of chemicals. At this concentration of salts (2,000 ppm), something of the order of one-half of the product is consumed in regeneration and rinse, so that the net product would be about 200 lb of water per lb of chemicals. Increasing the salt content of the raw water both lowers the gross yield and increases the requirements for rinse and regeneration. At 2,500 ppm salt content, the yield would not be over 100 lb of water per lb of chemicals. On the other hand, at 1,250 ppm salt content, the yield would increase to nearly 500 lb of water per lb of chemicals. Although progress is being made in reducing the rinse requirements for ion-exchangers, it is evident that major improvements must be made before they can compete on a yield basis with the vapor-compression still, except at very low salt concentrations.

Comparative Size and Weight of Equipment

If existing equipment of equal capacity is compared, the vapor-compression and direct-fired stills appear to weigh about the same, but the vapor-compression still is much the more compact type, occupying as little as one-half of the space occupied by a comparable direct-fired still. This comparison holds regardless of the salinity of the feed water. Since the capacity of an ion-exchange unit depends directly on the salinity of the feed, comparison of size and weight is

meaningless except at a specified salinity. If water of 2,500 ppm NaCl* is assumed, the weight of an ion-exchange installation producing about 6,000 g.p.d. is about one-third of a comparable vapor-compression still, whereas the space occupied is about the same as, or slightly less than, that occupied by the still. As the salinity of the feed decreases below this point, the yield of the ion-exchange equipment per unit weight and bulk of equipment increases rapidly. Within its limited range of effectiveness, then, the ion-exchange process offers outstanding advantages in compactness and mobility, with the vapor-compression still in second place; for sea water, the vapor-compression still leads in compactness and mobility as well as in efficiency.

Scale Control in Distillation Units

The greatest problem in the operation of distillation units, both direct-fired and vapor-compression, is the accumulation of scale in the evaporator shell. This reduces the output and efficiency of the still, and may in extreme cases cause failure of the unit. The usual method of combating the problem has been to take apart the evaporator shell after a specified number of hours of operation, or after the capacity has been reduced below the rate value by a given amount, and to remove the scale mechanically. Use of inhibited acids or acid salts to remove scale has been practiced to some extent, and thermal cracking—that is, dousing the hot interior coils of the evaporator with cold water, to crack off the scale by rapid contraction of the metal—is effective on some types of scale.

There has been considerable recent research on the nature and mode of formation of these scales, notably that by Langelier et al (10). These workers found that the nature and rate of formation of scale depend as much on the boiling temperature and on the rate of precipitation of the various compounds from supersaturated solutions as they do on the concentration and composition of the brine. For example, in distilling sea water, the scale formed in a low-pressure, direct-fired, double-effect evaporator was 87.7% calcium carbonate,

*This is about the economic limit of operation. The yield of water per cubic foot of resin per cycle is 171 gal, of which 130 are used in rinse and regeneration. Figures from A. H. Valles, Dorr Co.

whereas that formed in a vapor-compression still was 95.6% magnesium hydroxide.

It was found that the rate of scale accumulation could be very materially reduced by continuous circulation of concentrate from the evaporator shell through a layer of sand or other suitable particles. The deposition of insoluble salts tends to take place on the surfaces of this contact material, rather than in the evaporator coils. Comparative trials have been made by operating parallel vapor-compression distillation units with and without a "stabilizer," based on the contact principle. The internal condition of the still after 5,000 hours of operation with the stabilizer was comparable to that after only 500 hours of operation without the stabilizer. Thus the stabilizer would increase the interval between shut-downs for descaling by at least a factor of ten. Large stabilizer units are under trial in conjunction with large-capacity vapor-compression stills.

Indicated Lines of Investigation

For desalting sea water and other waters of equivalent salt content, research to improve the performance of the vapor-compression still and to develop larger units seems at present to offer the greatest promise. For waters of lower salt concentration, development of the ion-exchange process is strongly indicated; it is probable that the level of salt concentration at which ion-exchange can compete with distillation will be materially increased in the next few years. Some attention should be given to solar distillation; if the technical difficulties in the way of development of large installations can be overcome, this method would be of great value in many parts of the world. No immediate return is in sight from such investigations, but it is not impossible that a few original individuals, attacking the problem, might produce surprising results.

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MEMOIR OF DAVID EDWARD MOULTON

DAVID EDWARD MOULTON, an Honorary Member of the New England Water Works Association, President-Emeritus of the Maine Water Utilities Association and Attorney of the Portland Water District, passed away suddenly in his sleep on April 21, 1951.

Mr. Moulton was born in Falmouth, Me., on September 16, 1871, of old New England stock and received his early education in the public schools of Falmouth and Cape Elizabeth. He was graduated from Westbook Seminary in 1888 and later entered Yale Law School, being graduated as LL.B. in 1897 and as M.L. in 1898. After graduation he instructed in Yale Law School for one year.

He set up a law practice in South Portland in 1899 and represented the city of South Portland in the State legislature. He was that city's first Solicitor. In 1908 he opened a law office in Portland, where he specialized in corporate and public-utility law.

It was this specialty that first brought him into contact with the water-works profession, for he began serving the Portland Water District as its Attorney in 1908. Prior to that date he took part in the litigation between the Portland Water Co. and the Portland Water District which resulted in the organization of the latter and its acquisition of the works in 1908. At the time of his death Mr. Moulton was the District's oldest employee in point of service.

He was very active in the utility field and was one of the original incorporators of the Maine Water Utilities Association, which he served as President from its organization in 1925 until 1950, when he was elected President-Emeritus.

He was elected to membership in the New England Water Works Association in December, 1929, and to Honorary Membership in November, 1944.

A series of learned discussions on "Water Works Law", written by Mr. Moulton ten years ago, was collected and published by the Maine Water Utilities Association and widely distributed over the United States. He was also the author of several papers presented to

the New England Water Works Association and entered wholeheartedly into many discussion periods, his long association with the profession having given him a remarkable insight into problems other than legal.

Mr. Moulton did not confine his interest to water supply, but was very active in civic affairs in his community. He was a member of the Board of Directors of the Chapman National Bank and of the Cumberland Savings and Loan Association, as well as a member of the Board of Masonic Trustees of Portland.

He served as president of the Portland Farmers Club and held membership in the American Water Works Association, Maine Association of Engineers, The First Radio Parish Church, American Peony Society, American Jersey Cattle Club and the St. Petersburg Lawn Bowling Club. For 25 years he was a Trustee of Westbrook Seminary and Junior College, and for the past 20 years president of the Board of Trustees.

Much of Mr. Moulton's interest centered in Masonic affairs. He was initiated in Hiram Lodge of South Portland in 1899. Later he was Worshipful Master and was Grand Master of the Grand Lodge of Maine in 1924-1925. He was also a member of the Greenleaf Chapter, Portland Council and Portland Commandery and was Grand Commander of the Grand Commandery of Maine in 1933. He was also a member of the Scottish Rites and Commander-in-Chief of the Maine Consistory from 1928 to 1930. He received the Thirty-third degree, Honorary, at Pittsburgh in 1925.

In addition to his interest in Masonry, Mr. Moulton's hobbies were farming and horticulture. He had a farm at Falmouth, where could be found some of the best-bred Jersey stock in America, while his acres were devoted to raising the rarest varieties of peonies. In this way he engaged in a pleasant and profitable pastime.

SIDNEY S. ANTHONY

PROCEEDINGS

SEVENTIETH ANNUAL CONVENTION
BOSTON, MASS.
SEPTEMBER 10-12, 1951

The Seventieth Annual Convention of the New England Water Works Association was held at the Hotel Statler, Boston, Mass., on September 10, 11 and 12, 1951.

Monday, September 10

Morning Session

President Thomas R. Camp in the Chair.

The Annual Reports of the Secretary, Treasurer, Editor, Finance Committee, Committee on Legislation, Committee on Technical Program, Committee on Membership and Committee on Committees were presented and accepted.

Upon motion duly made and seconded, it was VOTED that the report of the Committee on Reciprocal Relations with the Institution of Water Engineers, to be presented later, be accepted and placed on file.

The President declared the polls closed and appointed as tellers Thomas S. Lawrence, Marshall S. Wellington and John F. Glacken.

The following reports of technical committees were presented and accepted: Committee on Ground-Water Supplies, Committee on Rainfall and Yield of Drainage Areas, Committee on Cast-Iron Pipe and Fittings, Committee on Reinforced-Concrete Pressure Pipe, Committee on Laying Cast-Iron Water Mains, Committee on Specifications for Steel Pipe, Committee on Standardization of Pipe Flanges and Fittings, Hydrant Specification Committee, Committee on Gate-Valve Specifications, Committee on Sluice-Gate Specifications, Fluid Permeability Committee, and Committee on Conservation, Development and Utilization of Water Resources. All the reports mentioned above are printed in this issue of the JOURNAL.

Upon motion duly made and seconded, it was VOTED to adopt the following resolution:

WHEREAS legislation is being proposed in the Congress to implement a National Water Policy and whereas the members of the New England Water Works Association are vitally concerned with water policy,

BE IT RESOLVED that the New England Water Works Association favors a National Water Policy which will lead to an economic development of the nation's water resources with collective action for management and payment of the costs at the lowest governmental level practicable for each development and with due regard to the possibilities of interstate coöperative action.

BE IT RESOLVED that the Federal Government should engage in the conservation and control of water resources only when the collective action of all of the people of the nation is necessary for accomplishment of the objective or when the benefits accrue to all the people of the nation, and

BE IT FURTHER RESOLVED that the Federal Government should participate in water resources development primarily in a fact-finding and advisory capacity. The Executive Committee of the New England Water Works Association is hereby directed and empowered to take action for the Association consistent with this resolve.

Secretary Knox announced the election of the following to membership in the Association: Thomas F. Coughlin, Superintendent, Water Dept., Wellesley, Mass.; Stephen E. Dore, Jr., Consulting Engineer, Coffin & Richardson, Boston, Mass.; William A. Fisher, Charles A. Maguire & Associates, Boston, Mass.; Alexander Good, Manager, Municipal Water Dept., Rowley, Mass.; Francis L. Hamill, President and Treasurer, Litchfield Water Co., Litchfield, Conn.; John J. Hoban, Assistant Superintendent, Buildings and Utilities, Logan Airport, Boston, Mass.; Merton R. Hodge, Superintendent, Unionville Water Co., Unionville, Conn.; Jose H. La Riva, U. S. A. Training Fellowship at Springfield, Mass.; Rev. Daniel Linehan, S.J.,

Director of Weston Observatory, Weston, Mass.; John R. Madden, Production Manager, Eureka Pipe Co., Lynn, Mass.; Rudolph E. Martin, Superintendent, Ridgefield Water Supply Co., Ridgefield, Conn.; Grant H. Potter, Partner, Charles A. Maguire & Associates, Providence, R. I.; J. Edgar Revelle, Dist. Sales Manager, Chicago Bridge & Iron Co., Boston, Mass.; George E. Symons, Consulting Engineer, Larchmont, N. Y.; Stayley H. Trask, President, Trask Artesian Well Co., Norwich, Conn.; Albert J. Wall, Superintendent, Public Works, Woburn, Mass.

Afternoon Session

This session was devoted to a Symposium on Fluoridation.

A paper on "Fundamentals of Water Fluoridation" was read by Harry A. Faber, Research Chemist, Chlorine Institute, Inc., New York, N. Y.

A paper on "Fluoridation Experience in New Britain, Connecticut" was read by George W. Wood, Chief Engineer, Board of Water Commissioners, New Britain, Conn.

A paper on "Progress and Experience with Fluoridation of Connecticut Water Supplies" was read by Warren J. Scott, Director, Bureau of Sanitary Engineering, State Department of Health, Hartford, Conn.

Tuesday, September 11

Morning Session

Superintendents' Round Table. There was a panel discussion on "Forestry and Watershed Management," with Harold W. Griswold, Consulting Engineer, Hartford, Conn., acting as Moderator.

* * * * *

PRESIDENT CAMP. I shall now receive the report of the tellers.

REPORT OF THE TELLERS OF ELECTION

To the New England Water Works Association:

The tellers at the election have counted the votes and the following is the result:

Total number of votes cast	437
For PRESIDENT: Frederick O. A. Almquist	424
Blank	13
For VICE-PRESIDENT: William B. Duffy	421
Blank	16
For DIRECTOR: Scott Keith	256
James M. Reilly	170
Blank	10
For TREASURER: William P. Melley	422
Blank	15

Respectfully submitted,

(*Signed*) MARSHALL S. WELLINGTON
JOHN F. GLACKEN
THOMAS S. LAWRENCE, *Chairman*

PRESIDENT CAMP. It is my pleasure at this time to announce the election of Frederick O. A. Almquist as President, of William B. Duffy as Vice-President, of Scott Keith as Director, and of William P. Melley as Treasurer.

Wednesday, September 12

Morning Session

A motion picture, "More Power to America—Water-Supply Program," was shown by the General Electric Co.

A paper on "Reconstruction of the Portland Water District" was read by Herman Burgi, Jr., Treasurer and General Manager, Portland Water District, Portland, Me.

A paper on "Highlights of Current Controlled Materials Plan for Water-Works Construction" was read by Walter L. Picton, Water and Sewage Works Advisor, Office of Program and Requirements, Defense Production Authority, Washington, D. C.

A paper on "Civilian Defense of New England—Recent Developments" was read by Albert D. O'Connor, New England Regional Director, Federal Civil Defense Administration.

Afternoon Session

A paper on "Limitations of Standard Methods for Evaluating Sanitary Quality of Water" was read by F. M. Gilcreas, Assistant Director in Charge of Laboratories for Sanitation and Analytical Chemistry, State Department of Health, Albany, N. Y.

A paper on "Recent Developments—Cambridge Water Supply" was read by Howard M. Turner, Consulting Engineer, Boston, Mass.

Evening

Through the courtesy of the Water and Sewage Works Manufacturers Association, Inc., a social hour was held in the ballroom foyer of the Hotel Statler, followed by a dinner in the ballroom, with music and entertainment.

Certificates of Honorary Membership were presented by President Camp to Theodore L. Bristol, Richard H. Ellis and Warren J. Scott.

AWARD OF THE DEXTER BRACKETT MEMORIAL MEDAL

PRESIDENT CAMP. Next in order of importance in the awards is the annual award for the best paper, the Dexter Brackett Memorial Award. I am going to ask Mr. Clarence Ahlgren, who represents the Award Committee, to make the presentation.

CLARENCE L. AHLGREN. Mr. President and members of the New England Water Works Association, and guests: In 1916 the New England Water Works Association established the Dexter Brackett Memorial Award. This was done to perpetuate the memory of Dexter Brackett, who was with the Boston Water Department and later the Metropolitan Water System, first as Chief of the Distribution System and then as Chief Engineer. Mr. Brackett was president of this Association during 1889 and 1890, and for several years was editor of the JOURNAL.

This is the 35th annual presentation of the medal. During that time 31 members have been awarded the memorial medal.

This year your committee, consisting of Donald W. Loiselle of the Bridgeport Hydraulic Co. as chairman, John B. Kennedy of Norwood, Mass., and Clarence L. Ahlgren of Manchester, N. H., were of the opinion that the most meritorious paper published in the JOURNAL in 1950 was entitled "The Chicopee Valley Aqueduct," by Stanley M. Dore, one of New England's leading engineers.

Mr. Dore is a graduate of Brown University, 1920, with a Bachelor of Science degree in Civil Engineering. He first worked in the designing division of the Providence Water Supply for seven years, on the Scituate Reservoir development for the city of Providence. For the next 22 years he worked for the Metropolitan District Water Supply Commission and its successor, the Construction Division of the MDC—for 12 of those years as designing engineer and for ten as deputy chief engineer. We are all familiar with his work on the Quabbin Reservoir development and on the project for the sanitary improvement of Boston Harbor. A little more than a year ago he became associated with Allegheny County Sanitary District of Penn-

sylvania, as deputy engineer in charge of design of sanitary improvements for metropolitan Pittsburgh. Allegheny County has gained one of New England's foremost engineers.

Mr. Dore, it is a great pleasure for me, on behalf of the New England Water Works Association, to present to you the Dexter Brackett Memorial Award for 1950.

STANLEY M. DORE. A certain racetrack habitué returned home and told his wife, "A peculiar thing happened to me today; as I leaned over to tighten my shoe-lacing at the track, somebody slapped a saddle on my back." His wife said, "What did you do?" And he said, "What could I do? I ran and came in first!"

Now, that story has no connection with this award. I was groping around for something to say for an acceptance speech and I asked Mrs. Dore what would be an appropriate story, and she said, "Why does it have to be appropriate?" I could not answer that one, so that I told the story anyway. [*Laughter.*]

Another story is that a young lady in a boarding house said that the new male member must have been terribly embarrassed when she caught him peeking over the transom. She was asked if she was excited, and she said, "Yes, I thought he would never get over it." [*Laughter.*] That has nothing to do with the award, either.

Now the next point, after deciding whether the stories should be told or not, was whether they were good enough, and Mrs. Dore said, "Why do they have to be good?" I could not answer that one, either, so that I am telling the stories anyway.

Of course, when you tell stories to a mixed gathering, there should be a razor-sharp division between those stories and the stories that you would tell to a male gathering, but Mrs. Dore maintains that my razor edge is rather dull. Therefore the next story may not quite comply with that razor edge. But a certain manufacturer of ladies' garments has limited the styles, according to the advertisement, to three types: the Russian type, the American type and the Salvation Army type. The Russian type outfits the masses, the Salvation Army type tries to help the masses, but the American type just makes mountains out of mole hills. [*Laughter.*]

I could not see any purpose to all this other than nonsense in

connection with the Dexter Brackett Award, except by way of emphasis, it being so foolish and so in contrast to the sincere spirit in which I accept this award. When I think back to such men as Frank Winsor, Karl Kennison, with whom I worked 25 years ago, and my present employer, it gives me a deep sense of humility and sincere appreciation in its acceptance. I thank you.

* * *

PRESIDENT CAMP. At the business meeting Monday morning, when reports were received, our Committee on Reciprocal Relations with the Institution of Water Engineers of London asked to defer the presentation of its report until this meeting. Mr. Percy Shaw will present that report.

PERCY A. SHAW. Mr. E. Sherman Chase is Chairman of this Committee, but he is not here, so that I shall pinch-hit for him. This is the report of the Committee on Reciprocal Relations with the Institution of Water Engineers.

REPORT OF THE COMMITTEE ON RECIPROCAL RELATIONS WITH THE INSTITUTION OF WATER ENGINEERS (LONDON)

September 12, 1951

To the New England Water Works Association:

The Committee on Reciprocal Relations with the Institution of Water Engineers of Great Britain presents herewith its report for the past year:

As stated in the Committee's report for 1950, the reciprocal arrangement called for the submission to the Institution of papers published in the JOURNAL of the Association for the years 1947 to 1950, for the Institution to make a selection of one considered worthy of the award of the Diploma presented by the Institution at four-year intervals to the member of your Association preparing such a paper.

The Institution has made its selection, which is the paper written by Stanley M. Dore, entitled "An Inverted Siphon for the Assabet River Crossing of the Wachusett Aqueduct", which was published in the JOURNAL of the N.E.W.W.A. for March, 1949. It is expected that Mr. Dore will give his paper in person at the Summer Meeting of the Institution in 1952, but the Institution of Water Engineers forwarded the Diploma to us for presentation here.

It is particularly fitting that the Diploma is presented at a time when the recipient is one of the Vice Presidents of the Association.

Respectfully submitted,

(*Signed*) E. SHERMAN CHASE, *Chairman*
LELAND G. CARLTON
PERCY A. SHAW

PERCY A. SHAW. Mr. Dore, it gives me great pleasure to present this Diploma in recognition of your good work in the waterworks field by the Institution of Water Engineers of Great Britain.

STANLEY M. DORE. Thank you very much, Mr. Shaw.

I have no set of stories prepared for its acceptance. I really did not expect this award to be made at this time, as I corresponded with Mr. Skeat of the London society and finally decided to try to attend the May meeting. He gave me the choice of December or May meetings, if I could come to one of them. It was utterly impossible for me to make the December meeting, but I have tentatively arranged with him to be there in May. Thank you very much.

COMMEMORATIVE AWARD

PRESIDENT CAMP. Since 1948 the New England Water Works Association has had a second prize, known as the Commemorative Award. The prize is awarded in memory of a deceased member of the Association who was prominent in the water-works industry. This year the award is made to Mr. Walton H. Sears, formerly of the Metropolitan District Water Supply Commission, for his paper, "Damages Paid on Account of Diversions from Ware and Swift Rivers for Water Supply of the Boston Metropolitan District." Mr. Sears is not present, so that the award will be sent to him.

The award is made in memory of Frank E. Winsor, late Chief Engineer, Metropolitan District Water Supply Commission, President of the New England Water Works Association in 1927 and later an Honorary Member, President of the Boston Society of Civil Engineers in 1929, and Vice-President of the American Society of Civil Engineers in 1930. Mr. Winsor was born in Rhode Island in 1870 and was a graduate of Brown University. He was the Chief Engineer of the new Scituate Water Supply at Providence, being appointed in 1915; and he was appointed Chief Engineer of the Boston Metropolitan District Water Supply Commission in 1926 and held that position until his death. This award is made in his memory.

* * *

PRESIDENT CAMP. We have two members who have reached the 25-year mark, Mr. Harold L. Field of Greenfield and Mr. Edward L. Randall of Wrentham. These gentlemen have been in the continuous service of their respective communities for 25 years. [*Presenting certificates.*]

FEDERAL BUREAUCRACY AND A FREE SOCIETY

PRESIDENTIAL ADDRESS
BY
THOMAS R. CAMP

ONE of the duties of the president of this association is to present an address at the end of his term of office. This is a privilege for me because it gives me the opportunity to tell you about some of the things which are worrying me, so that you can help me worry. I think we can do more than just worry about these problems, but early and continuous aggressive action will be required if we are to save our way of life. My concern is with the trend towards state socialism by our Federal Government.

This trend has been noticeable for many decades. It was accelerated during the depression by the New Deal with federal handouts of various sorts, was speeded up still more during World War II, and now threatens to get entirely out of hand. Every new function taken over by the Federal Government requires an appropriation and expenditures, and every new expenditure, for some strange reason, seems to require additional personnel on the federal payroll. Make no mistake about it, it will cost us more to have Uncle Sam do something for us than it would cost us if we did it ourselves. Moreover, federal assistance on local or regional endeavors means federal control. We are losing our free-enterprise system; the rights of the states are being seriously impaired, and concurrently our public morals are degenerating alarmingly.

In July, 1951, a report on "The New England Economy," prepared by the Committee on the New England Economy of the President's Council of Economic Advisers, was submitted to the President. The report contains the following statement: "We do insist, however, that New Englanders should reconsider their attitudes toward the Federal Government. They must decide whether, as federal operations continue to expand, New Englanders can stand idly by and shun federal aid of all kinds. New Englanders have to choose between

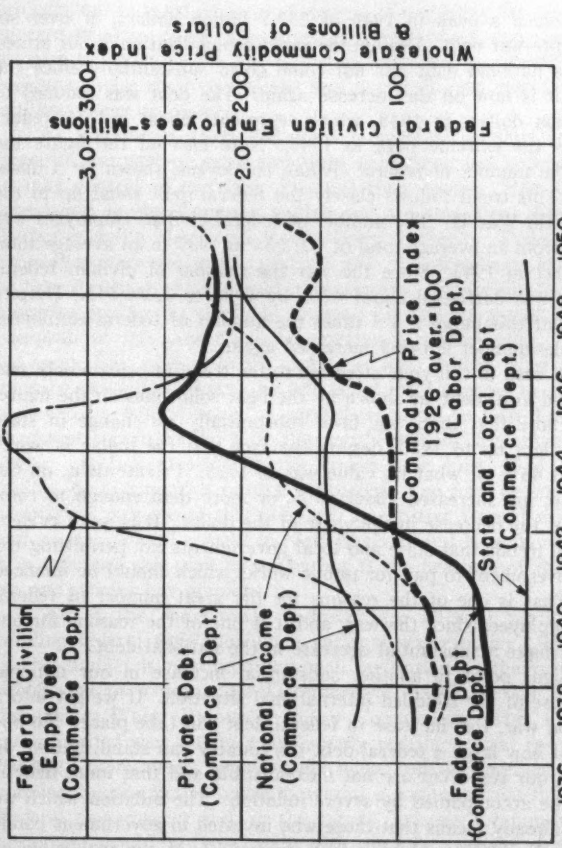
two alternatives: to oppose many federal programs without success and so to face a continuing and perhaps increasing drain of funds through Federal Government operations, or to yield to the trend of the times and, once it is clear that federal expenditures are to be made, to seek their fair share."

That, ladies and gentlemen, is a vicious and immoral statement to come from any government employee or official; and it indicates quite clearly that many have forgotten that they are servants of the people and are paid by our money. To accept a federal handout because it is "the trend of the times" is cowardly. If the federal operation is clearly for the benefit of all the people and has economic justification, we should support it. If, on the other hand, the federal operation is clearly unsound, we should not only refuse our share of the handout but do all in our power to stop the operation altogether.

We are currently in the greatest era of prosperity ever known to man. The total national income during 1949 was about $217,000,000,000, or about $1,450 for every man, woman and child. Preliminary figures for 1950 indicate a total national income of $235,600,000,000, or over $1,500 for every man, woman and child. Without question this great prosperity has been brought about by technological improvements, made possible by the free-enterprise system, but it is accompanied by gross waste of our natural resources and great extravagance by the Federal Government. It cannot last, because our resources are not inexhaustible.

On the accompanying figure, I have shown a number of curves which indicate what has happened since 1937. The national income is shown by a light broken line. It shows that there has been a 3.2-fold increase in national-income dollar value since 1938. The commodity price index, however, which is shown by the heavy broken line, has also increased by 2.3-fold. In other words, the dollar is worth only 43% of what it was worth in 1938; thus, the real increase in total income during this period is only 40% and, if the increase in population is taken into account, the per-capita income has increased less than 30%.

Now, let us look at the federal debt, which is shown by the heavy solid line on the graph. In 1938 the federal debt was $40,000,000,000, but it increased rapidly after 1941 because of World War II expendi-


Federal Civilian Employees (Commerce Dept.)
Private Debt (Commerce Dept.)
National Income (Commerce Dept.)
Federal Debt (Commerce Dept.)
Commodity Price Index 1926 aver.=100 (Labor Dept.)
State and Local Debt (Commerce Dept.)
Federal Civilian Employees-Millions
Wholesale Commodity Price Index & Billions of Dollars
3.0
2.0
1.0
300
200
100
1936
1938
1940
1942
1944
1946
1948
1950
Camp, Dresser & McKee Consulting Engineers, Boston 1951

tures, to reach a peak in 1945 of 252.7 billion dollars, or over six times the pre-war debt. Despite the rapid demobilization of our armed forces, the national debt has not come down substantially since the war, and it is now on the increase again. The debt was reduced to 216.5 billion dollars in 1948, which represents about a 15% reduction below the extreme peak in 1945. Note also on the figure the trend in the number of federal civilian employees, shown by a dash-dot line. This trend follows closely the federal debt trend up to the end of World War II. The number of federal civilian employees was increased from an average total of 902,055 in 1937 to an average total of 3,569,092 in 1945. Since the war the number of civilian federal employees was decreased about 42% by 1948 to 2,066,545. Despite the fact that this figure is 2.3 times the number of federal employees in 1938, the number is being increased again.

I now wish to call your attention to the trend in private debt and in state and local debt, as shown by the light solid lines on the figure. You will note that there has been substantially no change in state and local debt up to 1950, despite the fact that the dollar is worth only about 43% of what its value was in 1938. Private debt, on the other hand, has increased about 60%, or more than enough to compensate for the decrease in the value of the dollar. It is quite evident from these trends that state and local governments are permitting the federal government to pay for public works which should be financed locally. That is one of the reasons for the great number of federal civilian employees since the war, and it is one of the reasons for our failure to make a substantial decrease in the national debt.

All signs point to another substantial increase in our national debt because of the troubled international situation. If we get into a third world war, this increase in federal debt will take place. No one knows just how large a federal debt the country can stand, but we do know that our resources are not inexhaustible and that more debt is bound to be accompanied by severe inflation. The inflation which we have had already means that those who invested in government bonds to finance World War II have lost about 57% of the real value of their money.

Now, one of the things that you and I can do is to refuse to accept Federal Government handouts on local and state public-works

projects and to insist on local autonomy in managing the affairs which concern us only. We can instruct our congressmen and senators that we wish to return to the way of life in which towns, cities, states and regions manage their own affairs and pay their own way without federal assistance or control.

As you know, there has been a continuous effort for several years on the part of some ambitious politicians and federal agencies to take control of our New England river basins. Bills have been introduced in the Congress calling for a Connecticut River Valley Authority and a Merrimack River Valley Authority. Federal agencies claim that there are some 3,000,000 KW of undeveloped hydro power in New England which should be developed, despite the fact that engineering studies for the New England Council show that only about one-sixth of this power can be developed economically. Moreover, for every KW of new hydro power, at least 3 KW of steam power must be developed. After the refusal of the Congress to appropriate money for a federal study of natural resources in New England, the President appointed the New England-New York Inter-Agency Committee, which is to report to the President in June, 1954, on a plan for the development of natural resources. You may be sure that the underlying purpose of this plan will be greater federal expenditures and greater federal control in New England and New York. We can help influence this plan by appearing at the hearings of the Committee and voicing our opinions.

We of the water-works industry are affected particularly by pending federal legislation on a national water policy. The Bureau of the Budget is now studying such legislation as the result of the submission of a report on December 11, 1950, by the President's Temporary Water Resources Policy Commission. This Commission recommended that public water supply remain a local responsibility, but the Commission's policy would make full development of the remaining hydro-electric power potential a major responsibility of the Federal Government and, in the future, licenses for non-federal development would be issued only with the joint consent of the federal agencies. Inasmuch as hydro-electric power is the particular water resource of greatest monetary value, this policy would be an entering wedge to give the Federal Government complete control over all our

river valleys. Your Executive Committee has been struggling with this problem and with your coöperation will endeavor to assist in the working-out of a national water policy which will preserve the rights and powers of local governments.

In conclusion, I wish to state that my tenure of office has been a pleasant one. I am indebted to the Executive Committee and to the numerous other committees of the Association for their splendid coöperation in running the affairs of the Association. I owe my thanks particularly to our secretary, Joe Knox, and to Mrs. Melrose, who really operate the Association, to the Water and Sewage Works Manufacturers' Association, which, through Bill Brenchick, John Stewart, Bob Orth, Reg Hayes and others, has been so generous with exhibits and entertainment, and to Mrs. Kenneth Robie, who had charge of the ladies' entertainment.

It is now my pleasure to introduce to you your new president, Frederick O. A. Almquist.

PRESIDENT ALMQUIST. Mr. President and members of the New England Water Works Association and guests:

For two or three days now some of my friends have been asking me if I had my speech prepared for tonight. I think you will agree with me that the incoming President should have a very small part in the program tonight, and I am going to make it just that.

I wish to thank the membership for the confidence which they have placed in me and, in accepting this office, I am mindful of the responsibility which it entails. I am somewhat frightened as I start, as I look back over the past presidents and think of the capability of those presidents and the issues which I shall have to face. However, that fright vanishes a little bit when I look at the group of officers with whom I am to be associated, and whom you have placed in office. President Camp has mentioned the fact that our genial Secretary, Joe Knox, and his equally genial assistant, Mrs. Melrose, do a considerable share of the work, and, as I say, that fright vanishes quite a little and I look forward with quite a little optimism to the year ahead.

We are quite strong, I think. We are strong financially, thanks to our Treasurer, Bill Melley, who watches the pennies as they come in and go out.

President Camp has mentioned the fact that we passed the 1,000 mark in membership this year and that the largest membership we have ever had was 1,042. I should like to see our membership pass the greatest number that we have ever had, and I think that we can do it. We could take the slogan, "Ten Hundred and Forty-two in '52." That does not mean about 25 new members, however. Unfortunately we lose, through one form or another, 40 or 50 members a year. That means that we shall have to go out and get 50, 60 or 70 new members. I think we had over 100 new members during this past year, which was an excellent figure for our Membership Committee in their campaign.

I think many of you would be glad to know where the next convention is going to be held. It will be held in Connecticut, at the Hotel Griswold in Groton, and it is my pleasure to invite all of you to attend that convention next year. I think the dates are September 8, 9 and 10. I hope you will all be there.

In closing I should like to say once more that I hope I can uphold the traditions of this organization, which are high. I thank you.

There being no further business, I shall declare this convention adjourned and turn the rest of the program over to Mr. Brenchick.

[*Adjourned.*]

ANNUAL REPORT OF THE SECRETARY

Mr. President and Members of the New England Water Works Association: The Secretary herewith submits the following report of the changes of membership during the past fiscal year and the general condition of the Association.

The present membership is 992, constituted as follows: 13 Honorary Members, 817 Members, 2 Junior Members, 126 Associate Members and 34 Corporate Members.

MEMBERSHIP

				Total
September 1, 1950—Honorary Members, Total		12		
Withdrawals		2	10	
Elected	3		3	13
September 1, 1950—Members, Total		755		
Withdrawals:				
Resigned	15			
Died	14			
Dropped by Executive Committee	8	37	718	
Elected:				
September 17, 1950	9			
October 20, 1950	7			
November 16, 1950	2			
December 20, 1950	2			
January 18, 1951	5			
February 15, 1951	5			
March 15, 1951	26			
April 19, 1951	20			
May 17, 1951	8			
June 13, 1951	7			
August 3, 1951	8	99		
Reinstated: January 18, 1951	1			
April 19, 1951	1	2	101	819

September 1, 1950—Associates, Total		120		
Withdrawals:				
Resigned	2	2	118	
Elected:				
September 17, 1950	1			
January 18, 1951	1			
March 15, 1951	1			
June 13, 1951	1			
August 3, 1951	1		5	
Reinstated: September 17, 1950	1			
December 20, 1950	1			
June 13, 1951	1		3	126
September 1, 1950—Corporates, Total		33		
Withdrawals:				
Dropped by Executive Committee	1	1	32	
Elected:				
September 17, 1950	1			
June 13, 1951	1		2	34
September 1, 1951—Total Membership				992
September 1, 1950—Total Membership				921
			Gain	71

ELECTIONS

Members

September 17, 1950—Arnold G. Carey, Miguel T. Escribano, John E. Gahagan, Charles W. Harvey, Joseph C. Lawler, Jr., Ira P. Loring, Vincent Mascia, Elwood E. Smith and Ervin L. Welch. (9)

October 20, 1950—John P. Hennings, George A. Howland, III, Clarence F. Lamb, Byron O. McCoy, J. Carrell Morris, Philip W. Pease and Miner Stackpole. (7)

November 16, 1950—Manuel E. Azvedo and John F. Glacken. (2)

December 20, 1950—Morton F. Sampson and John G. Stewart. (2)

January 18, 1951—Samuel J. Bargh, Joseph N. Farnham, Jr., Harry R. Feldman, William G. Hartwell and Philip W. Sheridan, Jr. (5)
Reinstated—Wilbur D. Smith. (1)

February 15, 1951—Lendon F. Dutton, Angus D. Henderson, Rostislaff Nebolsine, I. Laird Newell and Wallace S. Pinkham. (5)

March 15, 1951—Dwight A. Agnew, Edward D. Barton, James C. Callahan, John J. Coleman, Thomas T. Craven, William E. Dobbins, Harold L. Garland, George F. Gay, Richard P. Grossman, Clarence R. Hall, Fortis E. Hart, Dwight A. Hogg, Stanley B. Johnson, John K. Kirn, Christian G. Kuehlke, Jr., George L. Legg, Joseph G. Lufkin, Charles K. Moore, John A. Morley, Louis Neleber, John S. O'Reilly, Peter F. Riopelle, Roy F. Amedee, Leo Trudelle, Sumner Smith and Henry Warner. (26)

April 19, 1951—John E. Anderson, Lew Brigham, Thomas E. Cass, Roger F. Duwart, Frank E. Fahlquist, John C. Finn, Edward V. Fitzpatrick, Raymond F. Ford, Alfred W. Garnell, A. Clayton Greenleaf, Miles L. Harris, Douglas Harwood, Maurice F. Hennessey, Edward C. Jordan, Albert L. Lash, Norman Low, Clifford S. Mansfield, Howard A. Mayo, Edgar G. Mitchell, Raymond A. Whipple and Julian H. White. (21)

Reinstated—John A. Hastings. (1)

May 17, 1951—Arthur H. Abbott, Robert R. Curtis, William J. C. Marshall, Jr., Henry M. Mautner, Vincent A. Morkus, Francis S. Rupprecht, Frank A. Shaw and Raymond E. Sweeney. (8)

June 13, 1951—Walter A. Arnold, Eben P. Lufkin, James Otis, Willard S. Pratt, John M. D. Suesman, Frank F. Wells and Henry L. Weston. (7)

August 3, 1951—John C. Adams, Jr., Ray L. Harris, Reginald F. Hayes, Joseph D. Keegan, James F. McGlame, Jr., Robert E. Moos, Ulderico M. Schiavone and William S. Warner. (8)

Associate Members

September 17, 1950—Kent County Galvanizing Company. (1)

Reinstated—Inertol Company. (1)

December 20, 1950—Reinstated—Joseph Dixon Crucible Company. (1)

January 18, 1951—Curry Oil Company. (1)

March 15, 1951—Johnson Plastic Corporation. (1)

June 13, 1951—P. K. Lindsay Company. (1)

Reinstated—Allis Chalmers Manufacturing Company. (1)

August 3, 1951—Perkins-Milton Company. (1)

Corporate Members

September 17, 1950—Manhasset-Lakeville Water District. (1)

June 13, 1951—Penacook-Boscawen Water Precinct. (1)

WITHDRAWALS

Members

Resigned: Gerald W. Blakeley, Walter C. Campbell, Paul J. Cerny, George E. Clapp, Dorothy E. Dimmers, Otis D. Fellows, Robert A. Glines, Christian G. Kuehlke, Jr., Martin J. Markham, William H. Perry, Jr., Lucretius H. Ross, Russell G. Starck, Norman S. Stearns, Donald B. Stevens and Frederick Timpson. (15)

Died: James W. Barrowclough, Luther E. Cotton, Timothy W. Good, Albert L. Lash, George E. Mann, Harry F. Martin, John E. McDonald, David E. Moulton, Cornelius R. D. Murphy, Joseph J. Murray, Edward J. O'Brien, Herbert F. Salmond, Arthur T. Safford and Edmund S. Sanderson. (14)

Dropped by the Executive Committee: John J. Desmond, Syed I. Husain, Wilpas V. Kallio, James P. McCarthy, William L. Morse, Manzil A. Rehman, Minot P. Secord and Dennis F. Sweeney. (8)

Associate Members

Resigned: Liquid Conditioning Corporation and Walker Process Equipment, Inc. (2)

Corporate Members

Dropped by the Executive Committee: Bureau of Water, Reading, Pa. (1)

RECEIPTS FOR THE FISCAL YEAR SEPTEMBER 1, 1950, TO SEPTEMBER 1, 1951

Entrance Fees	$ 325.00
Dues of Members of all grades	6,928.00
Dividends	528.25
Advertisements	5,576.75
Subscriptions	665.26
Journals	178.95
Membership Certificates	73.25
Total Receipts	$14,275.46

There is due the Association:

Dues	122.00
Advertising	157.50
Total	$14,556.96

Respectfully submitted,

(*Signed*) JOSEPH C. KNOX, *Secretary*

ANNUAL REPORT OF THE TREASURER

Boston, September 7, 1951

To William P. Melley, Treasurer,
New England Water Works Association,
Boston, Massachusetts.

We have examined the statement of assets and funds and the statement of cash receipts and disbursements of the general fund of the New England Water Works Association for the year ended August 31, 1951. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

We traced all recorded receipts into the depositary bank, verified the general fund bank account and petty cash fund as at August 31, 1951, and examined properly approved vouchers for all disbursements. We also verified by direct communication the investment funds on deposit in the Milton Co-operative Bank, and on September 4, 1951, we examined the United States Treasury savings bonds and the paid-up coöperative bank shares at the First National Bank of Boston.

In our opinion, the accompanying statement of assets and funds and the note thereon and the related statement of cash receipts and disbursements of the general fund present fairly the financial position of the New England Water Works Association at August 31, 1951, and the recorded cash receipts and disbursements for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(*Signed*) SCOVELL, WELLINGTON & COMPANY

STATEMENT OF ASSETS AND FUNDS (Exhibit A)

As at August 31, 1951

Assets

Securities, invested funds		
U. S. Treasury savings bonds G 2½s, 1954	$10,000.00	
Medway Co-operative Bank, 10 paid-up shares	2,000.00	
Milton Co-operative Bank, 25 shares series of June, 1940	4,097.50	
Sandwich Co-operative Bank, 10 paid-up shares	2,000.00	
Stoneham Co-operative Bank, 10 paid-up shares	2,000.00	$20,097.50
General fund		
Cash, First National Bank of Boston	$ 5,815.84	
In office	50.00	
	$ 5,865.84	
Furniture and fixtures	1,180.00	7,045.84
		$27,143.34

Funds

Invested funds		$20,097.50
General fund		
Balance, August 31, 1950	$ 6,144.63	
Transfer from invested funds	2,000.00	
	$ 8,144.63	
Less Purchase of Milton Co-operative Bank shares	300.00	
	$ 7,844.63	
Excess of disbursements over receipts, Exhibit B	(798.79)	
Balance, August 31, 1951		7,045.84
		$27,143.34

Note: The statement above, prepared on a cash basis, includes dues received in advance, $4,176, and employees' withholding tax, $121.39. It does not reflect the following:

Accounts receivable, dues	$122.00
Due on account of advertising	157.50
	$279.50

No depreciation has been taken on furniture and fixtures.

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS (Exhibit B)

General Fund

For the Year ended August 31, 1951

Receipts (exclusive of dues received in advance and employees' withholding tax)			
Initiation fees		$ 325.00	
Dues, 1950-1951 and prior years		2,752.00	
Interest		528.25	
From publication of Journal			
Advertisements	$5,576.75		
Subscriptions	665.26		
Sale of Journal	178.95	6,420.96	
Miscellaneous			
Membership certificates		73.25	
Total receipts			$10,099.46
Disbursements			
Publication of Journal			
Printing	$3,373.54		
Plates	609.47		
Reporting	254.37		
Stationery and postage	81.20		
Editor's salary	750.00		
Printing journal index	950.00		
Sundry	51.04	$6,069.62	
General and administrative			
Certificates of membership	$ 42.66		
Secretary's salary	750.00		
Assistants to secretary—salaries	2,980.00		
Treasurer's salary	200.00		
Printing, postage and stationery	264.98		
Office supplies and expense	162.83		
Office rent	1,060.00		
Electricity	95.44		
Telephone and telegraph	257.91		
Auditing	85.00		
Social security taxes	148.22		
Sundry	117.42	6,164.46	

Meetings and committees				
Water works school		125.00		
Printing, postage and stationery		1,162.39		
Convention expense		471.93		
Dinners		748.98		
Contribution to June conference	$150.00			
Less Refund for prior year	68.33	81.67		
Sundry expense		171.19	2,761.16	
Interest added to co-operative bank shares			114.50	
Total disbursements				15,109.74
Excess of disbursements over receipts (exclusive of dues received in advance and employees' withholding tax for current year)				($5,010.28)
Dues received in advance			$4,176.00	
Employees' withholding tax				
Receipts for current year		$121.39		
Less Payment for prior year		85.90	35.49	4,211.49
Excess of disbursements over receipts, Exhibit A				($798.79)
Balance, general cash, August 31, 1950			$4,964.63	
Transfer from invested funds			2,000.00	
			$6,964.63	
Less Purchase of Milton Co-operative Bank shares			300.00	6,664.63
Balance, general cash, August 31, 1951				
Represented by				
Cash in First National Bank of Boston			$5,815.84	
Cash in office			50.00	
				$5,865.84

ANNUAL REPORT OF THE EDITOR

To the New England Water Works Association:

The Editor submits herewith his report for the year ending August 31, 1951.

As has been customary in the past, the tables of financial figures, accompanying the report, are based upon total charges and accounts receivable, rather than actual cash received and disbursed. A detailed statement of the receipts and disbursements on account of the September and December, 1950, and March and June, 1951, issues of the JOURNAL is included in the report of the Treasurer.

In Table 1 is presented a statement of the material contained in the four issues of the JOURNAL for the past year, while in Table 2 is given a comparison of the JOURNAL for the past year with those for preceding years.

TABLE 1.—STATEMENT OF MATERIAL IN SEPTEMBER AND DECEMBER, 1950, AND MARCH AND JUNE, 1951, ISSUES OF THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION

	Papers	Proceedings	Total text	Index*	Advertisements	Cover and contents	Insert plates	Total pages	Total cuts
Sept., 1950	113	1	114	0	45	4	3	166	3
Dec., 1950	46	63	109	7	47	4	1	168	19
Mar., 1951	99	2	101	0	47	4	1	153	24
June, 1951	94	5	99	64	47	4	2	216	13
Total	352	71	423	71	186	16	7	703	59

*Including comprehensive index, 1882 to 1950.

Size. The four issues contained 703 pages, of which 423 were text.

Cost. The gross cost of the JOURNAL was $6,069.62, equivalent to $6.34 per member; the surplus was $351.34, equivalent to $0.37 per member.

Reprints. Reprints of papers have been furnished to authors at cost.

TABLE 2.—COMPARISON OF JOURNALS OF THE NEW ENGLAND WATER WORKS ASSOCIATION
Four Issues for Fiscal Year Ending August 31

	1942**	1943***	1944	1945	1946	1947	1948‡	1949‡‡	1950‡‡‡	1951*
Average edition (copies printed)	1,100	1,175	1,200	1,200	1,200	1,275	1,350	1,325	1,250	1,300
Average membership	803	798	799	806	820	846	876	905	921	957
Circulation at end of year	982	969	1,015	1,032	1,042	1,083	1,129	1,164	1,172	1,240
Pages of text	575	442	442	438	391	428	411	452	440	423
Pages of text per 1,000 members	716	554	553	543	477	516	469	500	477	442
Total pages, all kinds	757	616	621	630	586	632	615	661	666	703
Total pages per 1,000 members	943	772	777	782	715	747	702	731	723	734
GROSS COST:										
Total	$4,053.47	$4,234.68	$3,406.48	$3,734.19	$4,053.08	$4,193.60	$4,239.64	$5,016.44	$5,240.51	$6,069.62
Per copy	0.93	0.90	0.71	0.78	0.84	0.82	0.78	0.95	1.05	1.17
Per page	5.36	6.87	5.49	5.83	6.91	6.63	6.90	7.60	7.86	8.64
Per member	5.05	5.31	4.26	4.63	4.94	4.96	4.84	5.55	5.69	6.34
Per member per 1,000 pages	6.67	8.61	6.87	7.35	8.43	7.85	7.87	8.40	8.55	9.02
Per member per 1,000 pages of text	8.78	12.01	9.66	10.57	12.62	11.58	11.78	12.28	12.92	14.99
SURPLUS:										
Total	$534.72†	$609.81†	$407.21	$455.57	$162.33	$913.91	$1,990.81	$1,058.96	$1,294.73	$351.34
Per copy	0.12†	0.13†	0.08	0.09	0.03	0.18	0.37	0.20	0.26	0.07
Per page	0.71†	0.99†	0.66	0.72	0.28	1.44	3.32	1.60	1.94	0.50
Per member	0.67†	0.76†	0.51	0.57	0.20	1.08	2.28	1.17	1.41	0.37
Per member per 1,000 pages	0.88†	1.24†	0.82	0.90	0.34	1.71	3.71	1.77	2.12	0.53
Per member per 1,000 pages of text	1.16†	1.73†	0.92	1.29	0.51	2.52	5.55	2.59	3.20	0.88

*Including comprehensive index, 1882 to 1950.
**Including 45 pages of standard specifications.
***Including 28 pages of standard specifications.
†Net cost.
‡Including 54 pages of standard specifications.
‡‡Including 107 pages of standard specifications and recommended practice.
‡‡‡Including 25 pages of standard specifications.

Circulation. The present circulation of the JOURNAL is:

Members, all grades	992
Subscribers	160
Exchanges	23
Advertisers	65
Total	1,240

JOURNALS have been sent to all subscribers and to advertisers.

Respectfully submitted,

(*Signed*) GEORGE C. HOUSER,
Editor

ANNUAL REPORT OF THE FINANCE COMMITTEE

August 31, 1951

To the Executive Committee of the New England Water Works Association

Gentlemen:

The Finance Committee herewith submits its report on the budget for the year 1950-1951, and its recommended budget for the year 1951-1952.

The Committee has examined the figures obtained from the records of the Association during the past year, and has consulted with the Treasurer with reference to probable revenue and disbursements during the coming year.

The following changes have taken place in the membership list:

	Resigned	Deaths	Dropped	Elected	Gains
Members	15	14	8	101	64
Corporates			1	2	1
Associates	2			8	6
	17	14	9	111	71

The following tabulation is the estimated and actual budget for the past year:

REVENUE FOR 1950-1951

	Budget	Actual	Difference
Initiation fees	$ 150.00	$ 325.00	$ 175.00 +
Dues	7,000.00	6,928.00	72.00 —
Interest and dividends	500.00	528.25	28.25 +
Journal	6,200.00	6,420.96	220.96 +
Miscellaneous	50.00	73.25	23.25 +
	$13,900.00	$14,275.46	$ 375.46 +

EXPENDITURES FOR 1950-1951

	Budget	Actual	Difference
General and administrative	$ 6,400.00	$ 6,164.46	$ 235.54 +
Journal	5,300.00	5,119.62	180.38 +
Meetings and committees	3,200.00	2,761.16	438.84 +
Contingencies	500.00		500.00 +
Index for Journal	800.00	950.00	150.00 —
	$16,200.00	$14,995.24	$1,204.76 +

The estimated deficit was $2,300.00 and the actual deficit amounted to $719.78.

Reviewing the revenue items for the past year, there was a substantial increase in initiation fees, due to the fact that so many new members were added to the Association. As noted, there was a slight drop in the payment of membership dues, but not large enough to cause concern. The increased revenue from the Journal is due to the fact that some advertisers have been using two-color ads in the Journal and the charge of course is larger than for black-and-white ads; also we have supplied some colleges with a large number of back issues of the Journal, from which payment was forthcoming.

As for the disbursements, the actual spending was kept well within the confines of the budget, with the exception of the printing of the Index to the Journal, which exceeded the budget by $150.00.

In setting up the 1951-1952 budget, we suggest that the policy established in 1946, that of an unbalanced budget, should be continued.

BUDGET FOR 1951-1952

Revenue

Initiation fees	$ 150.00
Dues	7,500.00
Interest and dividends	550.00
Journal	5,850.00
Miscellaneous	50.00
	$14,100.00

Disbursements

General and administrative	$ 6,700.00
Journal	5,300.00
Meetings and committees	3,000.00
Contingencies	500.00
	$15,500.00

We refer you to the Treasurer's report for further financial details and to the Secretary's report for the changes in the membership listing.

Respectfully submitted,

(*Signed*) HENRY F. HUGHES, *Chairman*
HAROLD J. TOOLE
WILLIAM H. MCGUINNESS

ANNUAL REPORT OF THE COMMITTEE ON LEGISLATION

September 10th, 1951

To the New England Water Works Association:

Your Legislative Committee submits herewith its report on activities in the legislatures of the New England states during the year 1951.

Regular sessions were held in all six states and this report embraces the entire group.

In Connecticut the two following bills were of special interest and significance:

1. Fluoridation of Public Water Supplies

This bill was designed to make fluoridation of public and private water supplies mandatory beginning January 1, 1953, subject to the jurisdiction of the State Department of Health.

The bill was referred to the Legislative Counsel for study and report to the 1953 session of the Legislature.

2. The Relocation of Municipally-Owned Water and Sewer Lines Because of State Highway Construction

Under this bill the cost of relocating municipally-owned water and sewer lines, incidental to the construction or reconstruction of a state highway, would be regarded as a part of the cost of the highway and the highway commissioner would have been authorized to pay for the relocation of such lines.

The bill passed the House but was not acted upon by the Senate.

Several other measures were introduced during the course of the legislative session which either did apply, or might be interpreted as applying, to water supply. All failed of passage and it is desired to point out at this time that there were included in the group proposed bills definitely inimical to the best interests of the water-supply field. Continual vigilance is therefore necessary in the several states, to ensure the passage only of sound and progressive legislation as it may affect public water-supply systems and their operation.

In Maine the following measures were enacted into law:

Chapter 131—AN ACT RELATING TO FLUORIDE IN PUBLIC WATER SUPPLIES and reading:

"Sec. 122 B. Fluoride in public waters: rules and regulations. No Municipality, water district, individual or any agency operating a public water supply shall add any fluoride to any such water supply without written approval of the department of health and welfare. The department is authorized to make such rules and regulations as it deems necessary to carry out the provisions of this section."

Chapter 383, AN ACT RELATING TO WATER POLLUTION, which provides for the establishment of a Water Improvement Commission of specified organization and for the following purpose,

"It shall be the duty of the commission to study, investigate, and from time to time recommend to the persons responsible for the conditions, ways and means, so far as practicable and consistent with the public interest, of controlling the pollution of the rivers, waters and coastal flats of the state by the deposit therein or thereon of municipal sewage, industrial waste and other substances and materials insofar as the same are detrimental to the public health or to animal, fish or aquatic life, or to the practicable and beneficial use of said rivers, waters and coastal flats. The commission may in its discretion from time to time make recommendations to the legislature with respect to the classification of the rivers, waters and coastal flats and parts thereof within the state, based upon reasonable standards of quality and use which shall be consistent with the provisions of this chapter."

Eight other measures either creating, incorporating or otherwise relating to Water Districts in the State were passed into law.

The Massachusetts Legislature has been in session the entire year to the date of this report, with important matters still awaiting action and the date of prorogation as yet uncertain. However, we can report the following as enacted into law:

Chapter 22. AN ACT TO EXTEND THE TIME WITHIN WHICH COUNTIES, CITIES, TOWNS AND DISTRICTS MAY INCUR DEBT TO SECURE THE BENEFITS PROVIDED BY THE FEDERAL GOVERNMENT TO ASSIST THEM IN PUBLIC WORKS PROJECTS. This bill extends the time to July 1st, 1953.

Chapter 25. AN ACT RELATIVE TO THE ASKING OF PROPOSALS FOR CERTAIN CONTRACTS OF CITIES AND TOWNS. This measure makes mandatory the awarding of contracts by cities and towns, for construction work or the purchase of equipment, supplies or materials estimated at one thousand dollars or more, after advertising and acceptance of proposals, publicly opened, the

sole exception being cases of special emergency involving public health or safety.

Chapter 448. AN ACT MAKING FURTHER PROVISION FOR THE PROTECTION OF PUBLIC WATER SUPPLIES. This enactment defines the powers of the Mass. Department of Public Health as controlling agency over sources of public water or ice supply, whether used by any city, town, water supply, fire district, public institution, water or ice company or any person in the commonwealth.

Chapter 511. AN ACT ESTABLISHING THE WEATHER AMENDMENT BOARD AND DEFINING ITS POWERS AND DUTIES. This Board is established for the purpose of controlling the alteration or attempted alteration of natural weather phenomena by human or artificial means and consists of the Commissioners of Agriculture, Public Health and Conservation or their respective representatives.

Chapter 531. AN ACT PROVIDING FOR THE INTERCONNECTION OF THE WATER DISTRIBUTION SYSTEMS OF MUNICIPALITIES, DISTRICTS AND WATER COMPANIES.

Chapter 639 of the Acts of 1950 is hereby amended by inserting after section 15B the following section:—Section 15C. Any city or town, water district, water supply district, fire and water district, fire district or water company may contract with any other such city, town, district or water company for the interconnection of their water distribution systems and for providing and using any necessary pumping equipment for the supplying of water for domestic, fire and other purposes. The supplying of water for domestic purposes for extended periods shall be subject to the provisions of section forty of chapter forty of the General Laws. Such interconnections made with the works of the Metropolitan District Commission or any municipality, district or water company supplied therefrom shall be subject to the provisions of chapter ninety-two of the General Laws.

Three Chapters authorizing towns to appropriate sums of money for purposes of reimbursing certain individuals in connection with water-works matters were enacted.

Chapter 54 of the Resolves of 1951 provides for AN INVESTIGATION AND STUDY OF THE ADVISABILITY AND FEASIBILITY OF ESTABLISHING A SOUTHEASTERN MASSACHUSETTS WATER DISTRICT. An appropriation is called for but has not yet been passed.

House $80—RELATIVE TO THE FURNISHING OF WATER TO TOWNS IN THE METROPOLITAN WATER DISTRICT. This measure was referred to the next annual session for the second straight year.

House #974—BILL TO AUTHORIZE THE LEVY OF SPECIAL ASSESSMENTS TO MEET THE COST OF LAYING WATER PIPES IN PUBLIC WAYS, which was rejected by the Senate during the 1950 session, again failed to meet with the approval of that body.

House #1472—an Act relative to the furnishing of certain performance bonds in connection with contracts for certain public works, and relative to fair competition for bidders on the construction, reconstruction, alteration, remodeling or repair of certain public works by the Commonweath or any political subdivision thereof—and House #1473—an Act further regulating plans, specifications and bids on the construction, reconstruction, alteration, remodeling or repair of certain public works by the Commonwealth and cities and towns or any political subdivision thereof—after a great deal of debate and issuance of several substitute bills, were both rejected as House 2647.

In New Hampshire no statutes were enacted dealing with water-supply matters having a broad coverage. However, Chapter 190 of the Laws of 1951 authorized the State of New Hampshire to ratify the New England Interstate Water Pollution Control Commission.

Upon recommendation of the New Hampshire Water Pollution Commission, certain water supplies were placed in Class A category, reserving them solely for water-supply purposes.

In Rhode Island the only important legislation passed by the Rhode Island General Assembly at the last session relative to water-works operation was House 654, which created a Special Commission to Study the Water Resources and Facilities of the State of Rhode Island.

On Page 3 of this Act is the following clause:

"It shall be the purpose of said commission to study the water resources of the state and to recommend a comprehensive state policy with reference to the development of the surface, subsurface and percolating waters of the state, to recommend the methods through which such a policy should be carried into effect, and the ways and means of financing the same."

Another important clause in the Act is as follows:

"The commission shall have the power to investigate existing sources of water supply, both public and privately owned, including treatment plants, pumping stations and distribution systems, determining their ability to meet the domestic, industrial and fire demands of the communities which they serve in line with long range population studies, and to recommend additions or improvements in the interest of public health and the protection of property."

The 1951 session of the Vermont Legislature passed several laws and amendments to existing laws which have some direct or indirect relation to public water works.

Act 84. AMENDMENT OF THE 1949 LAWS MAKING VERMONT A MEMBER OF THE NEW ENGLAND INTERSTATE WATER POLLUTION CONTROL COMMISSION. This provides for the appointment by the governor of Vermont of three members to the New England Commission and also provides that the State Health Commissioner and the Commissioner of Water Resources be members of the New England Commission. An appropriation is provided for Vermont's share of the expenses of the New England Interstate Water Pollution Control Commission.

Act 119. AMENDMENT OF VERMONT STREAM POLLUTION CONTROL LAW. This gives the Water Conservation Board authority to take legal action against any person who permits waste of such kind and quality to enter a stream in Vermont as by itself or in combination with waste of other sources reduces the water below the classification set for it.

The Vermont 1949 Stream Pollution Control Legislation provided authority for the classification of streams and bodies of water. This classification system conforms with the standards of the New England Interstate Water Pollution Control Commission. The Vermont law provides that all water-supply reservoirs and all water flowing into such reservoirs within the State of Vermont are to be Class A.

Act 199. AUTHORIZES VERMONT MUNICIPALITIES TO PROCURE ASSISTANCE IN POLLUTION ABATEMENT. This new law requires the Water Conservation Board to make available to any Vermont municipality such assistance as may be required in matters relating to surveys, studies and plans of pollution abatement works (within the limits of the annual appropriation for the Water Conservation Board).

Act 231. ESTABLISHES A CIVIL DEFENSE AGENCY WITHIN THE STATE PUBLIC SAFETY DEPARTMENT. This law is quite long and detailed but in substance, among other things, it provides for mutual aid among towns and cities in this State and with other States and with the Federal Government. Authority is provided to make the most effective use of manpower, resources and facilities for dealing with any emergencies caused by enemy attack or sabotage. This includes control of medical and health services, engineering, plant protection and the restoration of public utilities. The civil defense law provides that the director of civil defense shall delegate to State Departments and Agencies appropriate civil defense responsibilities.

Act 106. AMENDMENT TO THE LAWS GOVERNING THE ESTABLISHMENT OF FIRE DISTRICTS. The Vermont laws formerly limited the maximum size of a fire district to 2 square miles. The amended law now permits the town selectment to establish the size of fire districts. It should be explained here that in Vermont a fire district is a municipal corporation similar to, but usually much smaller than, a village. The Prudential Committee is the governing body of a fire district. A fire district has legal authority to establish and build a water system and to issue bonds and levy taxes for such a water system in the same manner as a village does.

Act 220. CONSTRUCTION OF A NEW PUBLIC HEALTH BUILDING. This amends the 1949 legislation which provides for a new laboratory. The amended law now covers the construction of a laboratory workshop, and executive and administrative office building in Burlington.

Act 222. STATE DEPARTMENT OF HEALTH TO BE LOCATED IN BURLINGTON. This is an amendment to the 1949 law which placed part of the State Health Department in Montpelier. The entire State Health Department (except field personnel) will all be in Burlington from now on.

Respectfully submitted,

(*Signed*) MARK F. CROKER, *Chairman*
WARREN A. GENTNER
WILLIAM A. HEALY
PHILIP J. HOLTON, JR.
PETER C. KARALEKAS
EDWIN T. MCDOWELL
EDWARD S. TRACY

REPORT OF TECHNICAL PROGRAM COMMITTEE

September 7, 1951

To the New England Water Works Association:

The Chairman of the Technical Program Committee submits herewith the report of this committee.

During the current year technical programs have been arranged for the five Boston meetings and the Annual Meeting by this Committee. In addition, Mr. Sherman Rogers has been responsible for the excellent series of Superintendents' Meetings held in the morning of each Boston meeting and Mr. Fred Smith has done equally fine work in securing stimulating and instructive programs for the Chemists' sessions.

What I have to say in this, my third report, follows a very familiar pattern. In comparison with most technical societies, this Association has a heavy schedule of meetings, which places considerable burden on the Technical Program Committee to provide the requisite number of papers and at the same time have these papers diversified in scope, interesting in content, and well presented. As I have said before, since the morning Superintendents' and Chemists' sessions have tended to become more formalized, they compete with the afternoon sessions, particularly since many of our members, with interesting topics to present, prefer to give them informally in the morning rather than face a microphone on a dais in the austere atmosphere of the Georgian Room. This tendency is particularly unfortunate, since a frequent criticism of the programs is that they do not include more papers of a practical nature by superintendents. It seems to me that it would be worth while to take steps to reduce the formality of the after-luncheon sessions, both to enlarge the field of speakers and also to stimulate discussion from the floor.

At the same time all practical steps should be taken by all our members both to stimulate participation in the program by more of our members and also to call to the attention of the Program Com-

mittee interesting and new subjects in the field of water supply, particularly those pertaining to construction.

The Chairman wishes to take this occasion to thank the members of the Committee, the elected officers of the Association, and the Secretary and Assistant Secretary for the help and coöperation which they have given him during the past year.

Respectfully submitted,

(*Signed*) TRUMAN H. SAFFORD, *Chairman*
CLARENCE L. AHLGREN
GEORGE C. HOUSER
SCOTT KEITH
SHERMAN L. ROGERS
FRED E. SMITH
FRED P. STRADLING
GEORGE N. WATSON
MARSHALL S. WELLINGTON

REPORT OF COMMITTEE ON MEMBERSHIP

September 10, 1951

To the New England Water Works Association:

A mailing list of about 500 prospective members was prepared by the Committee, each member of the Committee furnishing an individual list of prospective members in his state. A printed form of invitation to join the Association was prepared and sent to these people. Some 300 invitations were sent out last spring, and recently an additional 200 invitations were sent out to those who had not replied to the first invitation.

The response to these invitations was most gratifying.

During the past year, 101 new members, 8 associate members and 2 corporate members have been elected, making a total of 111 new members. In addition to the above, there are 15 applications for membership now pending.

The thanks of your Committee is extended to the members of the Association for their coöperation and assistance in obtaining these new members.

It is suggested that the ensuing Committee prepare a form of follow-up letter to be sent to those who have not yet replied to the original invitations, in the hope that many other qualified and interested water-works men will join the Association.

Respectfully submitted,

(*Signed*) GEORGE W. COFFIN, *Chairman, Massachusetts*
JOHN J. BAFFA, *New York*
J. ELLIOTT HALE, *Maine*
CHARLES H. LAWRENCE, *Connecticut*
JOSEPH E. MOORE, *Vermont*
JAMES A. SWEENEY, *New Hampshire*
JAMES V. TURNER, *Rhode Island*

REPORT OF COMMITTEE ON COMMITTEES, 1950-1951

To the New England Water Works Association:

The Executive Committee of the Association in appointing a Committee on Committees for the year 1950-1951 included on that committee the members of the Executive Committee and Warren J. Scott, who has served as Chairman of the Committee since its inception in 1939. It was felt that this change would keep the Executive Committee in closer contact with the technical committees, the activities of which are one of the most important functions of the Association. The Committee on Committees has been in close touch with the various committees during the year and has been advised by them relative to the submission of reports at the Annual Convention.

It has been the policy of the Committee on Committees to recommend the discharge of inactive committees and those whose duties appear to be fulfilled. Some committees are joint committees with other associations, concerned primarily with the preparation and approval of standards, and progress may be expected to be delayed in getting out reports.

Listed below are committees which, in the opinion of this Committee, should be continued. In the case of most of the following committees, the committee chairmen have expressed the opinion that the committees should be continued:

* N.E.W.W.A. 8—Committee on Legislation.
* 9—Committee on Reciprocal Relations with the Institution of Water Engineers (London).
* 11—Committee on Survey of Ground Water Supplies in New England.
** 12—Committee on Rainfall and Yield of Drainage Areas.
16—Committee on Coëfficients for Friction in Pipe Lines.

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*Expects to submit report at 1951 Annual Convention.
**Expects to submit progress report at 1951 Annual Convention.

19—Committee on Water Quality and Treatment.
** 20—Committee to Report on Developments in Our Knowledge of Corrosion and Its Mitigation.
** 21—Committee on Specifications for Cast-Iron Pipe and Fittings (Sec. A.S.A.).
** 22—Committee on Reinforced Concrete Pressure Pipe (Joint A.W.W.A.).
23—Committee on Code for Pressure Piping (Joint A.S.M.E.).
** 24—Committee on Laying Cast-Iron Pipe (Joint A.W.W.A.).
** 25—Committee on Specifications for Steel Pipe (Joint A.W.W.A.).
** 26—Committee on Standardization of Pipe Flanges and Fittings (Sec. A.S.A.).
28—Committee on Steel Standpipes and Elevated Tanks (Joint A.W.W.A.).
** 31—Committee on Hydrant Specifications (Joint A.W.W.A.).
** 32—Committee on Gate Valves (Joint A.W.W.A.).
37—Committee on Federal Activities (Joint A.W.W.A.).
38—Committee on Fluid Permeability (Sec. A.S.A.).
39—Committee on Deep-Well Vertical Pumps (Sec. A.S.A.).
** 40—Committee on Water Rates Schedule (Joint A.W.W.A.).

Discontinuance of Committees

The chairmen of the following committees have recommended that their committees be discharged and the A.W.W.A., with whom these are joint committees, concurs:

* N.E.W.W.A. 29—Committee on Valve Box Frames and Covers (Joint A.W.W.A.).
* 33—Committee on Sluice Gates (Joint A.W.W.A.).

Changes in Committees and Establishment of New Committees

N.E.W.W.A. 10—Committee on Classification of Water Works Employees and Salaries was temporarily inactivated, and the Secretary directed to bring the matter of re-activation of this committee to the attention of the Executive Committee when it appeared advisable.

15—Committee on Cathodic Protection of Steel Tanks and Standpipes was discharged, and its work assigned to N.E.W.W.A. 20—Committee to Report on Developments in Our Knowledge of Corrosion and Its Mitigation.

19—Committee on Water Quality Tolerances for Industrial Uses was discharged, and a new committee under the same number, to be known as the Committee on Water Quality and Treatment, was established. The purpose of this committee is to keep the Association informed of developments and changes in this field.

41—Committee on Interstate Aid in Civil Defense was established, but appointees were not notified, pending approval of the Office of Regional Director of Civil Defense.

** 42—Committee on Conservation, Development and Utilization of Water Resources was established. The purpose of this committee is to keep the Association informed of any proposed Federal legislation regarding water resources.

Conclusion and Recommendations

It is recommended that the committees listed be continued as indicated and that the two committees listed be discontinued. The committee further recommends that activity on the part of all technical committees be encouraged.

Respectfully submitted,

THE COMMITTEE ON COMMITTEES

REPORT OF COMMITTEE ON GROUND WATER SUPPLIES

Recharging of Public Ground Water Supplies in New England

This committee met in Boston in February, 1951, and the subject for this report, "Recharging of Public Ground Water Supplies", was selected at that time. The desirability of bringing up-to-date the tabulation of Public Ground Water Supplies, published previously in the JOURNAL, was discussed, but in view of world conditions and activities in the field of civil defense it was not thought desirable to prepare such material for publication at this time.

Recharging of public ground-water supplies has been practiced in relatively few places in New England. All locations but one are in Massachusetts. While many ground-water sources are located near surface streams and ponds, to take advantage of high ground-water levels, this report is intended to cover situations where it is attempted to augment the natural yield of wells by artificial means.

The data included are not as complete as could be wished and it is possible that additional information may be obtained. It would be desirable in evaluating recharging efforts to know the quantity of water obtainable before and after recharging, the quality of the well water before and after recharging, the quality of the charging water, the area used for charging and, if possible, information regarding the character of the percolating material. This information is not all available in existing cases, but it is hoped that in the future it will be studied where recharging is contemplated or tried.

The information available at present is included in condensed form in the following tabulations:

	Estimated yield before charging (mgd)	Estimated yield after charging (mgd)	Increase (mgd)	Charging area (acres)	Color	Chlorides	Hardness	Alkalinity	pH	Iron
ATTLEBORO, MASS.										
Source: DUG WELLS	.600	.820	.220	2.5	3	4.5	22	13	6.0	.03
Charging Water: ORR'S POND (1)					17	4.6	17	12	6.5	.12
Source: GRAVEL-PACKED WELLS	.905									
Charging Water: SEVEN MILE R. (2)					15	4.8	20	10	6.7	.19
Source: GRAVEL-PACKED WELLS	.300	.750	.450		1	5.8	22	10	6.0	.04
Charging Water: WADING R. (3)					20	4.8	16	14	6.6	.16
BEDFORD, MASS.										
Source: DUG WELL		.060		.02	2	5.6	28	14	6.1	.12
Charging Water: KENDRICK POND										
BROOKLINE, MASS.										
Source: TUB. WELL AND GALLERY				4.3	50	9.9	45	45	6.4	2.3
Charging Water: CHARLES R.					69	9.5	—	19	6.8	.55
COHASSET, MASS.										
Source: DUG WELL		.500		.58	107	12.5	22	14	5.8	2.3
Charging Water: LILY POND					223	7.6	11	11	6.0	.65
NORTH EASTON, MASS.										
Source: DUG WELL	.300	.600	.300	.001	3	4.6	26	21	6.2	.05
Charging Water: FLYAWAY POND (4)					27	3.0	5.0	5.0	5.9	.07
HINGHAM, MASS.										
Source: COLLECTING WELL	1.0	2.0	1.0	7.5	10	9.1	44	37	9.1	.11
Charging Water: ACCORD AND FULLING MILL BR.					186	8.1	16	13	6.0	.50
					36	8.6	19	16	6.5	.17

	Estimated yield before charging (mgd)	Estimated yield after charging (mgd)	Increase (mgd)	Charging area (acres)	Color	Chlorides	Hardness	Alkalinity	pH	Iron
LEICESTER (Cherry Valley) MASS.										
Source: DUG WELLS	.080	.250	.170		20	7.4	19	15	6.6	.05
Charging Water: HENSHAW POND					5	4.6	16	13	6.7	.06
NEWTON, MASS.										
Source: DUG WELLS AND INFILTRATION CONDUIT (Avge.)	5.2	7.2	2.0	6.0	4	9.1	38	36	6.3	.01
Charging Water: CHARLES R.					69	9.5	—	19	6.8	.55
SALISBURY, MASS.										
Source: DUG WELL		.300		.2	4	6.5	39	40	6.7	.81
Charging Water: BROOK (5)										
WALTHAM, MASS.										
Source: DUG WELL #2					3	7.9	41	23	6.2	.03
Charging Water: STONY BR. RES. (6)					30	8.4	37	22	6.9	—
WINCHENDON, MASS.										
Source: NEW DUG WELL	.100	.200	.100		17	1.4	13	5	5.4	.46
Charging Water: BROOK										
NEW BRITAIN, CONN.										
Source: DRIVEN WELLS, WHITE BRIDGE	2.75	3.25	.50	1.	4	4.2	51	30	6.6	<0.1
Charging Water: CANAL AND POOL (7)					18	3.8	34	17	7.9	.12

REMARKS

1. Charging adjacent to walls of well.
2. Charging proposed.
3. Charging adjacent to wells.
4. Charging adjacent to walls of well.
5. Charging adjacent to well—has flooded over top.
6. Well was installed after reservoir was impounded, to take advantage of increased ground-water table.
7. Driven wells constructed along canal between two brooks, and piped to large caisson, near which pool was constructed. The yields given are for before and after pool construction. See Journal, NEWWA, Vol. 65, No. 2, June, 1951, page 150.

It is apparent from the table that in these cases there is a very wide range of ratio of filter area to yield increase (.003 to 11.3).

The color of well water is appreciably lower than that of the charging water in most cases. The chlorides are slightly lower in six cases and slightly higher in four. The hardness figures are slightly higher in the well waters than in the charging waters. The alkalinity is slightly higher in the well water, with one exception. The pH is slightly lower in the well water in eight cases and higher in two cases. The iron figures are lower in the well water in seven cases and higher in two cases. With the exception of color, the changes are of little apparent significance.

It is noted that, in several cases, the charging is adjacent to the walls of the wells and that in one case the well has been topped by the charging source. It would seem highly desirable to insure filtration of the surface water by preventing the charging water from reaching the walls or casings of the wells. The proper intervening distance might be dependent on the material providing the natural filter and also on the degree of pollution, existing or potential, of the charging-water source.

Respectfully submitted,

(*Signed*) LESLIE K. SHERMAN, *Chairman*
JOHN A. BELLIZIA
HOWARD H. POTTER
RALPH M. SOULE
M. L. BRASHEARS, JR.
FRANCIS J. LARIVIERE
WALTER J. SHEA
EDWARD L. TRACY

REPORT OF COMMITTEE ON RAINFALL AND YIELD OF DRAINAGE AREAS

To the New England Water Works Association:

Your Committee reported rather extensively relative to the drought of 1949-1950 and this report has been published in the December, 1950, JOURNAL of the New England Water Works Association. Since the filing of that report drought conditions throughout New England have been alleviated through normal rainfall. Rain in considerable amounts was received during the month of November, 1950, in practically all sections of New England and since that time has been nearly normal or above.

Considerable preliminary work has been done by the staff of the Division of Sanitary Engineering of the Massachusetts Department of Public Health toward compiling rainfall data in New England, covering the period 1942-1950, inclusive, but at present this material is not ready for publication. When the tabulations have been completed and checked they will be submitted to the Editor of the JOURNAL for publication. It is desired to continue the activity of this Committee, since it is possible that further information can be prepared with the assistance of the Water Resources Branch of the Geological Survey, showing the relationship between yield and storage on additional watersheds in New England.

Respectfully submitted for the Committee,

(*Signed*) FRANCIS H. KINGSBURY, *Chairman*

REPORT OF THE COMMITTEE ON SPECIFICATIONS FOR CAST-IRON PIPE AND FITTINGS

September, 1951

To the New England Water Works Association:

Committee A21 of the American Standards Association has concluded its twenty-fifth year of activity. Substantial progress has been made toward completing the following matters:

Revision of Specification A21.2 for Pit Cast Pipe for Water and Other Liquids.
Specification A21.6 for Pipe Centrifugally Cast in Metal Molds.
Specification A21.8 for Pipe Centrifugally Cast in Sand-Lined Molds.
Specification A21.10 for Short Body Fittings

Final issue of the foregoing standards awaits only the reconciliation of certain divergent views as to the phraseology of the text relating to coatings.

Specifications for Mechanical Joints (A21.11) are well advanced and now require only editorial refinement before submission to the sponsors.

Revision of Standard Specification A21.4 for Cement-Mortar Linings for Cast-Iron Pipe and Fittings is substantially completed.

It is hoped that the program of tests of full-size large fittings, interrupted by the war, can be resumed to provide data needed to permit establishment of revised standards for large fittings, including not only those with bell-and-spigot joints, but also those with mechanical joints. Such tests, however, will have to await the clarification of present world conditions.

Respectfully submitted,

(*Signed*) RICHARD HAZEN
ARTHUR L. SHAW

REPORT OF COMMITTEE ON REINFORCED CONCRETE PRESSURE PIPE

To the New England Water Works Association:

Your Committee consists of New England Water Works representatives of Committee E7B of the American Water Works Association. Committee E7B of that Association prepared a draft of Tentative Standard Specifications for Reinforced Concrete Water Pipe, Non-Steel Cylinder Type, Not Prestressed, and submitted the same for critical review and comment to all its membership in November, 1950.

Your Committee reviewed this draft and indicated general satisfaction with the draft, subject to numerous suggestions, recommendations and comments.

This draft was revised in March, 1951, to include the many suggestions by Committee E7B members and was resubmitted as the final draft of the tentative standards, subject to approval by the membership.

This draft of March, 1951, was approved by your Committee, with the definite exception that the section permitting the use of curing compounds be omitted and that, if such section was to be included, the exception was to be so recorded. The reason was that such curing, in our opinion, is a cheap substitute for proper water curing and that the purpose of these specifications is to give a good concrete pipe for low heads without a steel cylinder, it being of paramount importance to obtain a dense and durable concrete. To permit curing compounds did not seem to be consistent with this purpose.

This March, 1951, draft was submitted in April, 1951, to the Water Works Practice Committee. At a meeting in May, 1951, this Committee agreed that the specifications as revised in March, 1951, were generally acceptable, subject to the following three changes:

1. Addition to Sec. 3-1.1 Scope—to advise the user more specifically as to limitations and conditions under which this type of pipe should be used in water-works practice.

2. Elimination of references to membrane curing under Sec. 3-3.7.
3. Inclusion under Sec. 3-3.8 Testing of a suggested procedure for hydrostatic and crushing tests, so that the purchaser will have a guide for such tests if he desires to have them made.

These changes were made in a revision of the March, 1951, draft dated June 29, 1951, of which draft, as revised, your Committee has signified approval.

These specifications as written cover only the manufacture of Reinforced Concrete Pressure Pipe, without a steel cylinder and not prestressed, for sizes from 12 inches to 96 inches in diameter and designed for service where the maximum design head shall not exceed 100 feet.

Respectfully submitted,

(*Signed*) STANLEY M. DORE, *Chairman*
GEORGE A. SAMPSON

PROGRESS REPORT OF COMMITTEE ON LAYING CAST-IRON WATER MAINS

September 7, 1951

To the Members of the New England Water Works Association:

Your Committee on Laying Cast-Iron Water Mains had hoped to present a final report at this time, but regrets that it will be unable to do so. The Committee has kept in touch with the corresponding AWWA Committee, but can add little to its report of September 11, 1950.

The development of specifications for mechanical-joint pipe may make it desirable to include laying directions for such pipe in the specifications for installation of cast-iron water mains.

The jute packing industry has shown some interest in producing a packing material processed to overcome the bacterially undesirable characteristics of such material. The use of new materials and simplified procedures for disinfecting newly laid mains is under consideration.

Your Committee will welcome comments from members of the Association, pertaining to the use of hemp and jute packing, experiences in disinfecting water mains under difficult conditions, and failures of pipe joints made with the sulfur jointing compounds.

Respectfully submitted,

(*Signed*) W. S. MARINER, *Chairman*
GEORGE W. COFFIN

REPORT OF COMMITTEE ON SPECIFICATIONS FOR STEEL PIPE

To the New England Water Works Association:

Suggested revisions of the tentative standard specifications of the AWWA for steel pipe have been considered during the year, particularly those in connection with the placing of mortar lining in the steel pipes. These revisions seemed satisfactory and met many well-founded objections to the wording of the new tentative standards. When all suggested revisions have been considered, these tentative specifications will be forwarded to the Water Works Practice Committee for final adoption.

Respectfully submitted,

(*Signed*) STANLEY M. DORE
SCOTT KEITH

REPORT OF COMMITTEE ON STANDARDIZATION OF PIPE FLANGES AND FITTINGS

September, 1951

To the New England Water Works Association:

Your representatives on ASA Committee B16 on Standardization of Pipe Flanges and Fittings until recently have had no matters referred to them since their appointment in the fall of 1950, through a misunderstanding (now corrected) at ASA headquarters. We are able to report, however, that during this period two standards have been completed and issued:

Malleable-Iron Screwed Fittings, 300 lb. (ASA B16.19)
Steel Butt-Welding Fittings (revised) (ASA B16.9)

These are of only general interest to water-works men, as are most of the pending specifications, which it is expected will issue in the near future and which are listed below:

Ring Joint Gaskets
Non-Metallic Gaskets for Pipe Flanges
Wrought-Copper and Bronze Solder-Joint Fittings
Malleable-Iron Screwed Fittings, 150 lb. (revised)
Cast-Iron Screwed Drainage Fittings (revised)
Steel Pipe Flanges and Flanged Fittings (revised)

The progress of these specifications will be observed, so that any features vitally concerning this Association can be brought to the attention of the membership.

Respectfully submitted,

(*Signed*) RICHARD HAZEN
ARTHUR L. SHAW

REPORT OF HYDRANT SPECIFICATION COMMITTEE

To the New England Water Works Association:

The Hydrant Specification Committee wishes to report progress. It is expected that a final report can be made within a few months.

Respectfully submitted,

(*Signed*) ROGER W. ESTY, *Chairman*
HARRY U. FULLER
HAROLD W. GRISWOLD

REPORT OF COMMITTEE ON GATE VALVE SPECIFICATIONS

September 10, 1951

To the New England Water Works Association:

Your Committee on Gate Valve Specifications submits the following report for the year ending September, 1951.

The situation remains the same as reported last year, with the draft of the revised specifications prepared by Mr. Carl Simons of the Darling Valve Company still under study.

It is recommended that the Committee be continued for another year.

Respectfully submitted,

(*Signed*) HAROLD W. GRISWOLD, *Chairman*
LELAND G. CARLTON
WALTON H. SEARS

REPORT OF COMMITTEE ON SLUICE GATE SPECIFICATIONS

September 10, 1951

To the New England Water Works Association:

Your Committee on Sluice Gate Specifications, appointed last October, finds that there is no interest on the part of the sluice gate manufacturers or the A. W. W. A. in advancing the present specifications from the existing "tentative" status to a full standard.

Accordingly it is recommended that your Sluice Gate Committee be discharged.

Respectfully submitted,

(*Signed*) HAROLD W. GRISWOLD, *Chairman*
WALTON H. SEARS

REPORT OF FLUID PERMEABILITY COMMITTEE

To the New England Water Works Association:

The Sectional Committee on Fluid Permeation, Z-59, of the American Standards Association issued a progress report in June, 1951. The objectives of this Committee are as follows:

1. Define the term "permeability" and outline the mechanics of fluid permeation, as restricted to ideal homogeneous fluids and to media with which there is no interaction.
2. Establish a standard unit of permeability and the mathematical symbol of permeability.
3. Rename other terms in the field of fluid permeation that have been called "permeability" in the past.

The Committee consists of about 35 members from many interested societies and the New England Water Works Association has a representative. Nine of the members were former members of the Subcommittee on Ground-water of the American Geophysical Union for 1944-1945. Discussion was initiated by asking these Sub-committee members three questions:

1. Should the coëfficient of permeability depend only on the structure of the material, or should some other name be used to express this property in view of the fact, as now generally used, the coëfficient of permeability is not independent of properties of the fluid or the combined properties of the fluid and the material?
2. Should a name be coined, or is there a suitable one in existence, for expressing the combined properties of the material and fluid for practical application in one local area?
3. What are the parameters that should be included in the equation of flow of fluids that relate only to the structure of the material?

These same questions were put to most of the newly appointed members of the American Standards Association Committee in 1949. Replies are published in the progress report in detail.

After all members of the Committee have had sufficient time to discuss these replies, it is planned to submit more specific proposals to the members for consideration.

Respectfully submitted,

(*Signed*) STANLEY M. DORE

REPORT OF COMMITTEE ON CONSERVATION, DEVELOPMENT AND UTILIZATION OF WATER RESOURCES

September 10, 1951

To the New England Water Works Association:

The Committee on Conservation, Development and Utilization of Water Resources is a new committee, appointed by the Executive Committee on August 3, 1951, to follow developments in Federal legislation in connection with water resources, in order that the Association will be prepared to take appropriate action. The appointment of the Committee was prompted by the receipt of a letter, dated May 15, 1951, from the National Water Conservation Conference of Washington, D. C., soliciting a reply from the New England Water Works Association to the following:

1. Has your organization arranged for a study of the recommendations of the President's Water Resources Policy Commission?
2. Have you singled out one or more of the recommendations of the Commission for support or opposition when enabling legislation is submitted to Congress?
3. Please list the recommendations you will support, and
4. Recommendations you will oppose.

The National Water Conservation Conference consists of representatives of the water interests from 42 states, coöperating to promote local and state participation in plans for water-resources development and to preserve the integrity of state water laws, looking toward the development of a sound national land and water policy. In view of the vital interest of the members of the New England Water Works Association in the formulation of a sound national water policy, your Executive Committee believes that the Association should take a position on the various issues involved in a national water policy and should lend its support to the enactment of appropriate legislation. In order that the Executive Committee may act with power

in this matter, it is essential that the Association agree on a general policy at this meeting. Your Committee has been instructed to draw up a suitable policy for your consideration. The proposed policy is submitted below in the form of a resolution. Before requesting you to act on this resolution, the Committee presents below a brief history of developments in the matter of a national water policy.

In August, 1947, the Engineers' Joint Council, the coördinating body for the five national engineering societies, took steps to institute the creation of a national water policy commission, charged with the investigation and reporting upon the several elements affecting the orderly and economical development of the water resources of the country. In 1948 the National Water Conservation Conference presented a memorandum to the Hoover Commission, suggesting the establishment by the Congress of a national water policy, which stated in part, "Water conservation, utilization and control is carried on today by various Federal agencies under regulations and laws adopted at various times which are not adequately integrated. Often action by Congress has been prompted by expediency and by unrelated public demand from various parts of the country. The body of law regulating the activities of Federal agencies in the water field has grown up like Topsy. The Nation in this important endeavor has in the past proceeded and at the present time continues to proceed in a haphazard way." In 1948 the report of the Policy Committee of the American Water Works Association used similar language in recommending the development of a national water policy.

During the past several years the Bureau of Budget, in attempting to review the economic justification of water-resources projects proposed for appropriation, concluded that a complete revision of national water policy was needed and instigated the appointment by the President of the temporary Water Resources Policy Commission on January 3, 1950. In response to an invitation by this Commission, the Engineers' Joint Council in June, 1950, filed with the Commission a "Statement of Desirable Policy with Respect to Conservation, Development, and Use of National Water Resources." The President's Water Resources Policy Commission submitted its report December 11, 1950.

Many of the recommendations of the President's Commission closely parallel those of the Engineers' Joint Council Statement—as, for example, that public water supply remain a local responsibility and that ascertainable, direct dollar benefits become reimbursable to the Federal Government. It is also recommended that irrigation and public power be divorced and that a pre-essential to irrigation undertakings be a finding by the Department of Agriculture of a need for additional productive land, after a full consideration of the increase in rate of production on existing lands.

In the fields of hydro-electric power and of project evaluation, the Engineers' Joint Council and the President's Commission are far apart. The Commission's policy would make full development of the remaining hydro-electric power potential a major responsibility of the Federal Government, and in the future licenses for non-federal development would be issued only with the joint consent of the Federal agencies. With respect to the evaluation of projects, the Commission recommends clear-cut accounting of costs, but it suggests that the appraisal include secondary social, cultural, and economic benefits. The Commission states, "The Government has come to be recognized as an agency for social and economic action which need not follow the rules of the private capital market in order to obtain the necessary capital or to make investment decisions."

The important conclusions of the Statement of the Engineers' Joint Council are as follows:

"Conservation and control of the waters of the United States are in the national interest, but not necessarily a function of the Federal Government. On the contrary, that which can be done by the individual should be done by him; and that which requires collective action should be done at the lowest governmental level practicable. The Federal Government should engage in the conservation and control of waters only when the collective action of all of the people of the nation is necessary for accomplishment of the objectives. Such collective action through the medium of the Federal Government is justified for only two purposes:

1. To do those things which are essential to the national defense, or otherwise of substantial benefit to all of the people throughout the nation, and

2. To aid in the financing of the cost of construction of works for the benefit of a limited number of people on terms equitable to all other citizens of the nation.

"In discharge of the first function, the Federal Government is acting as trustee in the disbursement of tax revenues on a non-reimbursable basis for the general benefit. It follows that such expenditures should be made for those purposes which will produce the greatest benefits to the nation as a whole. This responsibility goes far beyond any determination of feasibility. It requires a determination of what is best, not merely what is good.

"In its performance of the second function, the Federal Government is basically acting as a banker responsible for the soundness of his loan. It is fundamental to this function that such loans should be repaid with interest so long as there is a national debt, and that the period of amortization should not exceed the useful life of the works. It is also fundamental to this function that those who benefit directly from the construction of such works for the conservation and control of water should repay all costs properly allocable to the production of such benefits. Furthermore, where indirect benefits will accrue to a region in greater degree than to the nation as a whole, the people in that region should repay a like proportion of all costs not allocable to production of direct benefits."

Your Committee believes that sound river-basin policies are essential. There are reasons to agree with the Engineers' Joint Council that action should be taken at the lowest governmental level practicable. Your Committee believes that Federal participation in water-resources development should be limited to fact-finding and advice, except where the project is essential to the national defense or is of substantial benefit to all the people throughout the nation. Your Committee believes that the cost of works should be borne by those who benefit by them. Accordingly, the following resolution is offered for your consideration:

"WHEREAS legislation is being proposed in the Congress to implement a National Water Policy and whereas the members of the New England Water Works Association are vitally concerned with water policy,

"*BE IT RESOLVED* that the New England Water Works Association favors a National Water Policy which will lead to an economic development of the nation's water resources with collective action for management and payment of the costs at the lowest governmental level practicable for each development. *BE IT RESOLVED* that the Federal Government should engage in the conservation and control of water resources only when the collective action of all of the people of the nation is necessary for accomplishment of the objective or when the benefits accrue to all the people of the nation, and *BE IT* further *RESOLVED* that the Federal Government should participate in water resources development primarily in a fact-finding and advisory capacity. The Executive Committee of the New England Water Works Association is hereby directed and empowered to take action for the association consistent with this resolve."

Respectfully submitted,

(*Signed*) THOMAS R. CAMP, *Chairman*
BYRON O. MCCOY
JOSEPH C. KNOX

COMMITTEES OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1951-1952

N.E.W.W.A.—1. *Committee on Technical Program:* Fred E. Smith, *Chairman,* Clarence L. Ahlgren, George C. Houser, Paul F. Howard, Kenneth F. Knowlton, Robert W. Moir, James W. Reilly, Sherman L. Rogers, Fred P. Stradling, George N. Watson and Marshall S. Wellington.

2. *Committee on Northern New England Meeting:* Edward S. Brown, Jr.

3. *Committee on Southern New England Meeting:* Henry Campbell.

4. *Committee on Finance:* Henry F. Hughes, *Chairman,* Harold J. Toole and Thomas S. Lawrence.

5. *Committee on Membership:* George W. Coffin, *Chairman,* John J. Baffa, Lendon F. Dutton, Joseph E. Moore, Howard H. Potter, James A. Sweeney and James V. Turner.

6. *Committee on Library:* Karl R. Kennison, *Chairman,* and Ariel A. Thomas.

7. *Committee on Committees:* Frederick O. A. Almquist, *Chairman,* Stanley M. Dore, William B. Duffy, Roger G. Oakman, Allan F. McAlary, Scott Keith, Sidney S. Anthony, Thomas R. Camp, William P. Melley and Warren J. Scott.

8. *Committee on Legislation:* Mark F. Croker, *Chairman,* Warren A. Gentner, William A. Healy, Philip J. Holton, Jr., Peter C. Karalekas, Edwin T. McDowell and Edward L. Tracy.

9. *Committee on Reciprocal Relations with the Institution of Water Engineers* (England): E. Sherman Chase, *Chairman,* Leland G. Carlton and Percy A. Shaw.

10. *Committee on Classification of Water Works Employees and Salaries:* (Temporarily inactivated).

11. *Committee on Survey of Ground Water Supplies in New England:* Ralph M. Soule, *Chairman,* John A. Bellizia, M. L. Brashears, Jr., Francis J. Lariviere, Howard H. Potter, Walter J. Shea, Leslie K. Sherman and Edward L. Tracy.

12. *Committee on Rainfall and Yield of Drainage Areas:* Francis H. Kingsbury, *Chairman,* John A. Bellizia, Allan T. Gifford, Peter C. Karalekas, Karl R. Kennison, Harvey B. Kinnison, Francis J. Lariviere, Ralph M. Soule, Miner R. Stackpole, Howard M. Turner and William A. D. Wurts.

16. *Committee on Coefficients for Friction in Pipe Lines:* Richard H. Ellis, *Chairman,* E. Shaw Cole, Allan T. Gifford, F. W. Haley and Byron O. McCoy.

19. *Committee on Water Quality and Treatment:* Clair N. Sawyer, *Chairman.*
20. *Committee to Report on Developments in Our Knowledge of Corrosion and Its Mitigation:* J. Carrell Morris, *Chairman,* Howard E. Bailey, Herman Burgi, Jr., Donald C. Calderwood, Richard H. Ellis, I. Laird Newell, Ellis A. Tarlton and Frank J. Thiery.
21. *Committee on Specifications for Cast-Iron Pipe and Fittings* (Sectional Committee under American Standards Association): Arthur L. Shaw and Richard Hazen.
22. *Committee on Reinforced Concrete Pressure Pipe* (Joint with American Water Works Association): Stanley M. Dore, *Chairman,* George W. Coffin and George A. Sampson.
23. *Committee on Code for Pressure Piping* (Joint with American Society of Mechanical Engineers): Thomas F. Wolfe.
24. *Committee on Laying Cast-Iron Pipe* (Joint with American Water Works Association): W. S. Mariner, *Chairman,* and George W. Coffin.
25. *Committee on Specifications for Steel Pipe* (Joint with American Water Works Association): Thomas R. Camp, *Chairman,* and Chester J. Ginder.
26. *Committee on Standardization of Pipe Flanges and Fittings* (Sectional Committee under American Standards Association): Arthur L. Shaw and Richard Hazen.
28. *Committee on Steel Standpipes and Elevated Tanks* (Joint with American Water Works Association): George A. Sampson, *Chairman,* Howard E. Bailey, Herman Burgi, Jr., and Henry E. Halpin.
31. *Committee on Hydrant Specifications* (Joint with American Water Works Association): Roger W. Esty, *Chairman,* and Harold W. Griswold.
32. *Committee on Gate Valves* (Joint with American Water Works Association): Harold W. Griswold, *Chairman,* Leland G. Carlton and Walton H. Sears.
37. *Committee on Federal Activities* (Joint with American Water Works Association): Clarence I. Sterling, Jr.
38. *Committee on Fluid Permeability* (Sectional Committee under American Standards Association): Stanley M. Dore.
39. *Committee on Deep-Well Vertical Pumps* (Sectional Committee under American Standards Association): Scott Keith.
40. *Committee on Water Rate Schedules* (Joint with American Water Works Association): Percy A. Shaw, *Chairman,* Warren A. Gentner and Edwin T. McDowell.
42. *Committee on Conservation, Development and Utilization of Water Resources:* Thomas R. Camp, *Chairman,* Joseph C. Knox and Byron O. McCoy.

INDEX OF ADVERTISERS

	Page
Atlas Mineral Products Co.	xxiv
Badger Meter Mfg. Co.	Following front cover
Bailey, Howard E.	ii
Brown Company	xi
Builders-Providence, Inc. Division of Builders Iron Foundry	v
Camp, Thomas R.	ii
Cast Iron Pipe Research Assn.	xxxi
Cement Lined Pipe Co.	iii
Centriline Corporation	Following front cover
Chapman, R. E.	ii
Crosby, Irving B.	iv
Eddy Valve Co.	xix
Eureka Pipe Co., Inc.	xxiv
Fay, Spofford & Thorndike	ii
Flexible Sewer Rod Equipment Co.	xxii
Ford Meter Box Co.	Following front cover
Gunite Restorator	ii
Haley & Ward	ii
Hays Mfg. Co.	xvii
Hersey Mfg. Co.	vi
Hilco Supply	xiii
Hughes, Edward F., Co.	iii
Hydraulic Development Corp.	xii
Keasbey & Mattison Company	xxvi
Kennedy Valve Mfg. Co.	xv
Knowles, Morris, Inc.	ii
Koppers Company, Inc.	Following front cover
Layne-New York Co., Inc.	iii
Leadite Co.	Back cover
Leggette, R. M.	ii
Lock Joint Pipe Co.	Following front cover
Maher, D. L., Co.	iii
Metcalf & Eddy	ii
Morris Machine Works	xviii
Mueller Co.	Following front cover
National Water Main Cleaning Co.	x
Neptune Meter Co.	ix
Northrop & Co.	xi
Omega Machine Co. (Division of Builders Iron Foundry)	xxi
Pierce-Perry Co.	iii
Pipe Founders Sales Corp.	xxii
Pirnie, Malcolm	iii
Pitometer Co.	iii
Pittsburgh Equitable Meter Co.	Following front cover
Joseph G. Pollard Co., Inc.	xiii
H. R. Prescott & Sons, Inc.	xi
% Proportioneers, Inc. %	Following front cover
Red Hed Mfg. Co.	vii
Rensselaer Valve Co.	xxv
Reppucci, C. & Sons, Inc.	iii
Ross Valve Mfg. Co.	xxiii
Smith Mfg. Co., The A. P.	Following front cover
Turbine Equipment Co.	xvi
U. S. Cast Iron Pipe and Foundry Co.	xxxii
Utilities Supply	xxii
Wallace & Tiernan	xx
Warren Foundry and Pipe Corp.	xxi
Welsbach Corporation	xiv
Weston & Sampson	iii
Whitman & Howard	iii
Wood, R. D., Co.	Following front cover
Worthington Pump and Machinery Corp.	viii

(Classified index on page xxvii)

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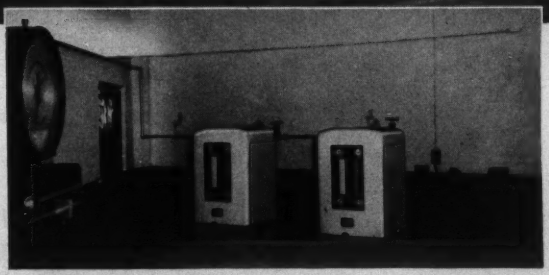

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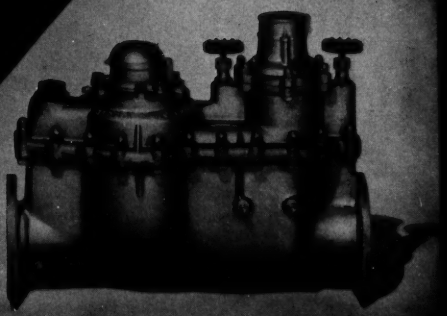

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Fig. 238

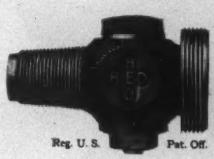

Fig. 227

Fig. 227A

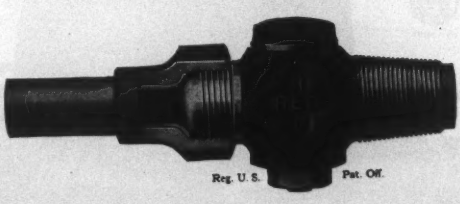

Fig. 438&A

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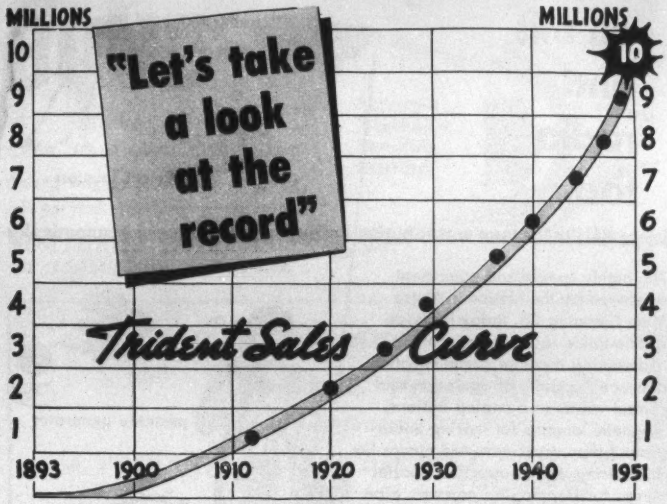

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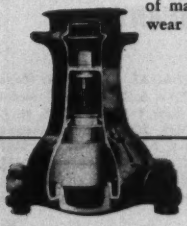

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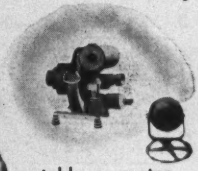

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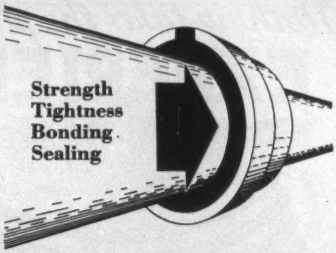

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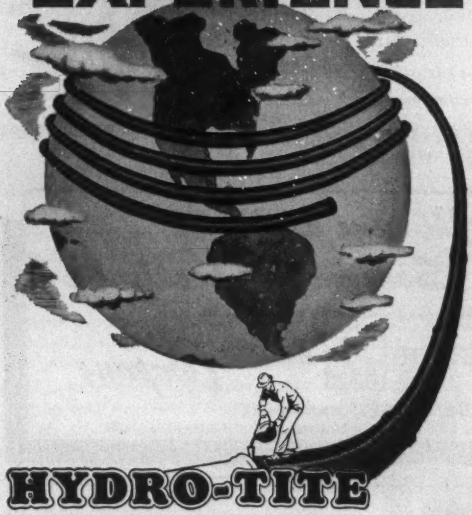

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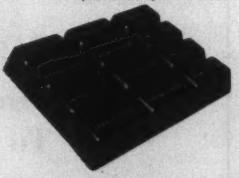

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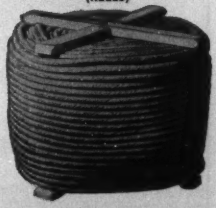

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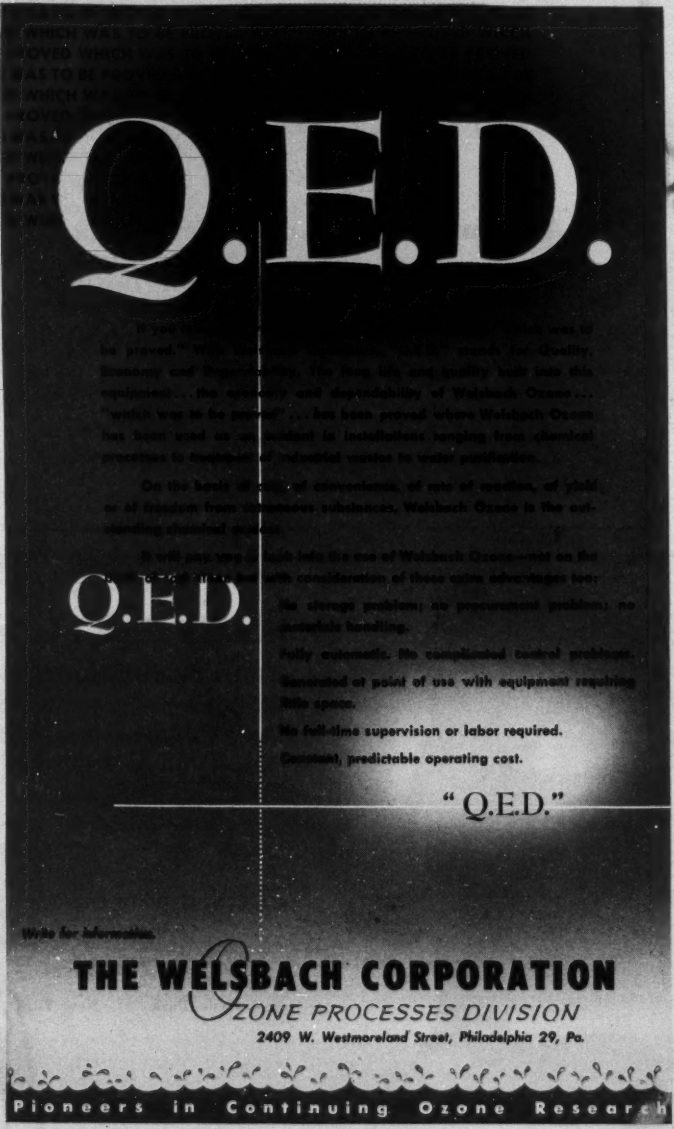
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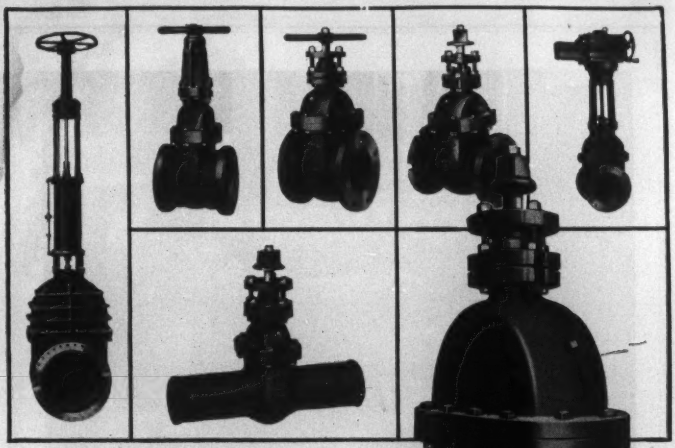

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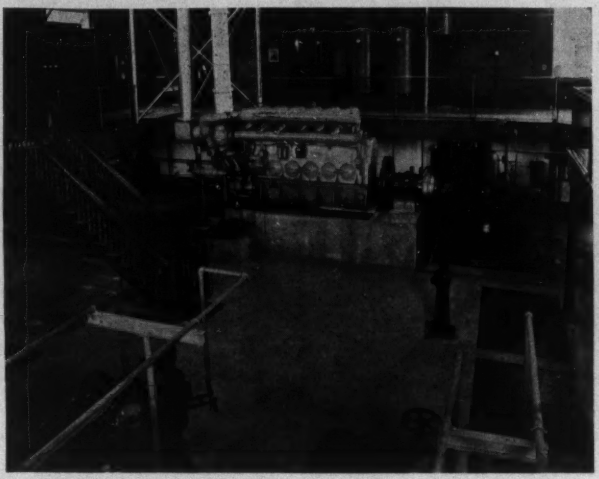

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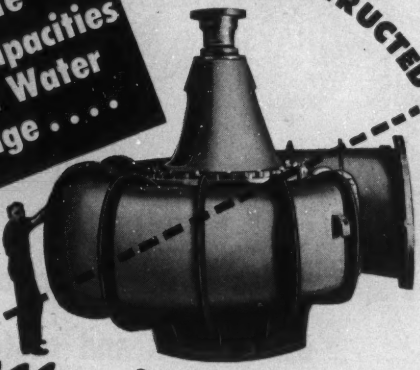

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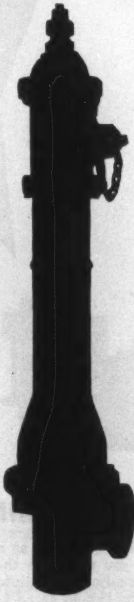

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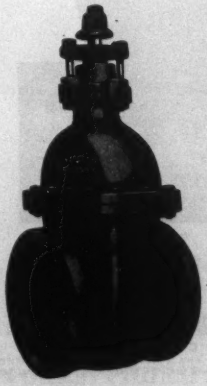

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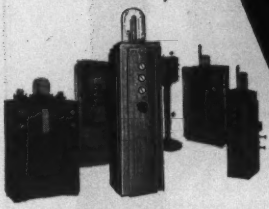

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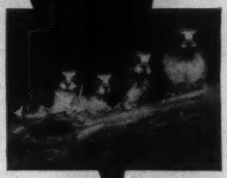

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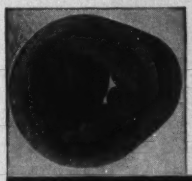

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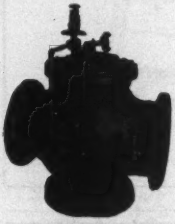

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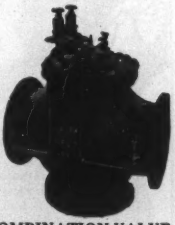

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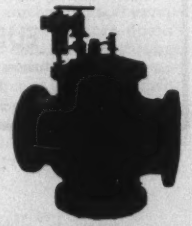

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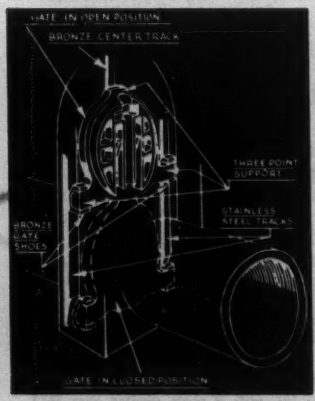

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CLASSIFIED DIRECTORY OF ADVERTISEMENTS

ASBESTOS-CEMENT PIPE.
Keasbey & Mattison Company xxvi

BRASS GOODS.
Eureka Cement Lined Pipe Co. xxiv
Hays Mfg. Co. xvii
Hilco Supply xiii
Mueller Co. ..... Following front cover
Pierce-Perry Co. iii
Red Hed Mfg. Co. vii
Smith Mfg. Co., The A. P. ..... Following front cover

CALKING MACHINERY AND TOOLS.
Hydraulic Development Corp. xii
Mueller Co. ..... Following front cover
Northrop & Co. xi

CAST IRON PIPE. (See Pipe, Cast Iron)

CEMENT LINED PIPE. (See Pipe, Cement Lined.)

CHEMICAL FEED APPARATUS.
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) v
Omega Machine Co. (Division of Builders Iron Foundry) xxi
% Proportioneers, Inc. % ..... Following front cover
Wallace & Tiernan Co., Inc. xx

CHLORINATORS.
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) v
% Proportioneers, Inc. % ..... Following front cover
Wallace & Tiernan Co., Inc. xx

CLEANING WATER MAINS.
Flexible Underground Pipe Cleaning Co. xxii
National Water Main Cleaning Co. x

COCKS, CURBS AND CORPORATIONS.
Eureka Cement Lined Pipe Co. xxiv
Hays Mfg. Co. xvii
Mueller Co. ..... Following front cover
Pierce-Perry Co. iii
Smith Mfg. Co., The A. P. ..... Following front cover

CONCRETE PIPE. (See Pipe, Concrete.)

CONTRACTORS' EQUIPMENT.
Hydraulic Development Corp. xii
Northrop & Co. xi

CONTRACTORS.
Layne-New York Co. iii
Maher, D. L. Co. iii
Reppucci, C. & Sons iii

CURB BOXES.
Eureka Cement Lined Pipe Co. xxiv
Hays Mfg. Co. xvii
Hilco Supply xiii
Mueller Co. ..... Following front cover
Pierce-Perry Co. iii
H. R. Prescott & Sons, Inc. xi

DIAPHRAGMS, PUMPS.
% Proportioneers, Inc. % ..... Following front cover

ENGINEERS.
Bailey, Howard E. ii
Camp, Dresser and McKee ii
Crosby, Irving B. vi
Fay, Spofford and Thorndike ii
Haley and Ward ii
Knowles, Morris, Inc. ii
Metcalf and Eddy ii
Pirnie Engineers, Malcolm iii
Weston and Sampson iii
Whitman and Howard iii

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

ENGINES. (See Pumps and Pumping Engines.)

EQUIPMENT. (See Contractors' Equipment.)

FEED WATER FILTERS.
- % Proportioneers, Inc. %.....Following front cover
- Ross Valve Mfg. Co., Inc.....xxiii

FILTRATION PLANT EQUIPMENT.
- Builders-Providence, Inc. (Divn. of Builders Iron Fdry.).....v
- % Proportioneers, Inc. %.....Following front cover

FLAP VALVES.
- Eddy Valve Co.....xix

FLEXIBLE JOINTS.
- U. S. Pipe and Foundry Co.....xxxii

FURNACES.
- Hilco Supply.....xiii
- Hydraulic Development Corp.....xii
- Leadite Co., The.....Back cover
- Mueller Co.....Following front cover
- Northrop & Co.....xi
- Pollard Co., Joseph G.....xiii
- H. R. Prescott & Sons, Inc.....xi

GATE VALVES. (See Valves.)

HOSE, SUCTION AND CONDUCTION.
- H. R. Prescott & Sons, Inc.....xi

HYDRANTS, FIRE.
- Eddy Valve Co.....xix
- Hilco Supply.....xiii
- Kennedy Valve Mfg. Co.....xv
- Mueller Co.....Following front cover
- H. R. Prescott & Sons, Inc.....xi
- Rensselaer Valve Co.....xxv
- Smith Mfg. Co., The A. P.....Following front cover
- Wood, R. D., Co.....Following front cover

HYDRANTS, PUMPS.
- Hilco Supply.....xiii
- H. R. Prescott & Sons, Inc.....xi

LEAD PIPE. (See Pipe, Lead.)

LIQUID CHLORINE.
- Brown Co.....xi

METERS, OIL AND WATER.
- Badger Meter Mfg. Co.....Following front cover
- Builders-Providence, Inc. (Divn. of Builders Iron Fdry.).....v
- Hersey Mfg. Co.....vi
- Neptune Meter Co.....ix
- Pipe Founders Sales Corp.....xxii
- Pittsburgh Equitable Meter Divn.....Following front cover
- Worthington-Gamon Meter Co.....viii

METER COUPLINGS.
- Badger Meter Mfg. Co.....Following front cover
- Ford Meter Co.....Following front cover
- Hays Mfg. Co.....xvii
- Hersey Mfg. Co.....vi
- Mueller Co.....Following front cover
- Neptune Meter Co.....ix
- Red Hed Mfg. Co.....vii
- Smith Mfg. Co., The A. P.....Following front cover
- Worthington-Gamon Meter Co.....viii

METERS (Venturi Type.)
- Builders-Providence, Inc. (Divn. of Builders Iron Fdry.).....v

METER BOXES.
- Ford Meter Co.....Following front cover
- Mueller Co.....Following front cover

METER TESTERS.
- Badger Meter Mfg. Co.....Following front cover
- Ford Meter Co.....Following front cover
- Mueller Co.....Following front cover
- Neptune Meter Co.....ix

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

OZINATION EQUIPMENT.
Welsbach Corp. xiv

PIPE, ASBESTOS-CEMENT
Keasbey & Mattison Company xxvi

PIPE, BRASS.
Hilco Supply xiii
Pierce-Perry Co. iii
H. R. Prescott & Sons, Inc. xi

PIPE, CAST IRON (and Fittings.)
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) v
Cast Iron Pipe Research Association xxxi
Hilco Supply xiii
Pipe Founders Sales Corp. xxii
H. R. Prescott & Sons, Inc. xi
U. S. Cast Iron Pipe and Foundry Co. xxxii
Warren Foundry and Pipe Co. xxi
Wood, R. D., Co. ..... Following front cover

PIPE, CEMENT LINED.
Cast Iron Pipe Research Association xxxi
Cement Lined Pipe Co. iii
Eureka Cement Lined Pipe Co. xxiv
Pipe Founders Sales Corp. xxii
U. S. Cast Iron Pipe and Foundry Co. xxxii

PIPE, COATING AND LININGS.
Centriline Corp. ..... Following front cover
Koppers Company, Inc. ..... Following front cover

PIPE, CONCRETE.
Lock Joint Pipe Co. ..... Facing front cover

PIPE CUTTING MACHINES.
Pollard Co., Joseph G. xiii
Smith Mfg. Co., The A. P. ..... Following front cover

PIPE JOINTING MATERIAL.
Atlas Mineral Products Co. xxiv
Hilco Supply xiii
Hydraulic Development Corp. xii
Leadite Co., The ..... Back cover
Northrop & Co. xi

PIPE, LEAD.
Pierce-Perry Co. iii
Red Hed Mfg. Co. vii

PIPE LINING.
Centriline Corp. ..... Following front cover

PIPE, PRESTRESSED CONCRETE.
Lock Joint Pipe Co. ..... Facing front cover

PIPE, WROUGHT IRON AND STEEL
Pierce-Perry Co. iii

PLUG VALVES.
Eddy Valve Co. xix
Hays Mfg. Co. xvii
Mueller Co. ..... Following front cover
Pittsburgh Equitable Meter Divn. ..... Following front cover

PITOMETERS.
Pitometer Co., Engrs. iii

PORTABLE AIR COMPRESSORS. (See Air Compressors.)

PRESSURE REGULATORS.
Hilco Supply xiii
Mueller Co. ..... Following front cover
Pittsburgh Equitable Meter Divn. ..... Following front cover
H. R. Prescott & Sons, Inc. xi
Ross Valve Mfg. Co., Inc. xxiii

PROVERS, WATER.
Badger Meter Mfg. Co. ..... Following front cover

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

PUMPS AND PUMPING MACHINES.
Layne-New York Co., Inc. ... iii
Hilco Supply ... xiii
Maher Co., D. L. ... iii
Morris Machine Works ... xviii
H. R. Prescott & Sons, Inc. ... xi
Ross Valve Mfg. Co., Inc. ... xxiii
Turbine Equipment Co. ... xvi

RATE CONTROLLERS AND GAUGES.
Badger Meter Mfg. Co. ... Following front cover
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) ... v

SHEAR GATES.
Eddy Valve Co. ... xix
Mueller Co. ... Following front cover

SLEEVES AND VALVE TAPPINGS.
Eddy Valve Co. ... xix
Hilco Supply ... xiii
Mueller Co. ... Following front cover
H. R. Prescott & Sons, Inc. ... xi
Rensselaer Valve Co. ... xxv
Smith Mfg. Co., The A. P. ... Following front cover

SUPPLIES AND TOOLS.
Hilco Supply ... xiii
Hydraulic Development Corp. ... xii
Leadite Co., The ... Back cover
Mueller Co. ... Following front cover
Northrop & Co. ... xi
Pierce-Perry Co. ... iii
Pollard Co., Joseph G. ... xiii
H. R. Prescott & Sons, Inc. ... xi

TAPPING MACHINES.
Hays Mfg. Co. ... xvii
Mueller Co. ... Following front cover
Red Hed Mfg. Co. ... vii
Smith Mfg. Co., The A. P. ... Following front cover

TAPPING SLEEVES. (See Sleeves and Valves, Tappings.)

VALVE BOXES.
Eddy Valve Co. ... xix
Hilco Supply ... xiii
Kennedy Valve Mfg. Co. ... xv
Mueller Co. ... Following front cover
Pierce-Perry Co. ... iii
Pipe Founders Sales Corp. ... xxii
H. R. Prescott & Sons, Inc. ... xi
Smith Mfg. Co., The A. P. ... Following front cover
Wood, R. D., Co. ... Following front cover

VALVE INSERTING MACHINES.
Mueller Co. ... Following front cover
Smith Mfg. Co., The A. P. ... Following front cover

VALVES, CHLORINE.
Wallace & Tiernan Co., Inc. ... xx

VALVES, GATE.
Eddy Valve Co. ... xix
Hilco Supply ... xiii
Kennedy Valve Mfg. Co. ... xv
Mueller Co. ... Following front cover
Pierce-Perry Co. ... iii
H. R. Prescott & Sons, Inc. ... xi
Rensselaer Valve Co. ... xxv
Smith Mfg. Co., The A. P. ... Following front cover
Wood, R. D., Co. ... Following front cover

VALVES, REGULATING.
Mueller Co. ... Following front cover
Ross Valve Mfg. Co., Inc. ... xxiii

WATER WASTE DETECTION.
Pitometer Co., The ... iii

WELL CONNECTIONS.
Red Hed Mfg. Co. ... vii

WELLS, GRAVEL, FILTER AND DRIVEN.
Edward F. Hughes Company ... iii
Maher Co., The D. L. ... iii

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Throughout the U.S.A.

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FOR WATER, GAS, SEWERAGE AND INDUSTRIAL SERVICE

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